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## Pittsburgh and Electrochemistry.

In view of the very full report of the proceedings of the Pittsburgh meeting of the American Electrochemical Society, which will be found elsewhere in this issue, it will be sufficient here to emphasize the most remarkable feature of this remarkable convention. This was the exceedingly hearty and enthusiastic welcome which Pittsburgh—all industrial Pittsburgh—extended to her electrochemical visitors. The Society was royally entertained through the four days. The courteous welcome extended by the leading industrial and public men of the city was reflected with friendly sincerity by the daily press. But Pittsburgh's hospitality was shown most splendidly and liberally by the wide-open doors of all her important industrial establishments. The series of visits and excursions was certainly delightful and will long be remembered by all those who had the good fortune to attend them. The most remarkable point, however, is that all this would have been simply impossible a few years ago, since Pittsburgh could not have shown so much interest in electrochemistry. Now the commercial success of electric steel refining has changed everything. It is another proof that the American Electrochemical Society was founded at the right time and that its formation was a necessity. The Society has always done the right thing at the psychological moment in its career, and at the right moment the Society went to Pittsburgh.

\* \* \*

Pittsburgh is now taking an interest in electric steel refining. There is no doubt about this fact. Nor can there be any doubt that when Pittsburgh undertakes to do something, it will be done in the most effective and successful manner. As we have said before, it requires no particular flight of fancy to think of Pittsburgh as a coming electrochemical center, as a center of electric-furnace activity for steel refining. And the commercial beauty of this coming development is that it must be a benefit all around—a benefit to the consumer by giving him better or cheaper steel, and a benefit to the iron and steel industry which gets a new important tool in the electric furnace, that does not impair in the least, but increases the usefulness of the existing installations. The electric furnace will not put anybody out of business. This is a fact that ought to be emphasized, as such is not often the case in new commercial developments. This evolution, being logical and natural, would have come, of course, whether the American Electrochemical Society had held a meeting in Pittsburgh or not. But that the past meeting will tend to accelerate this evolution—the Society acting as a catalytic agent—there can be no doubt; and in this sense it may be said, as was remarked by one of the speakers at the meeting, that future generations will probably point to the Pittsburgh meeting as the dawning of the new era of electric steel refining in this country.

## The Duplex Process.

The duplex process, in form of the combination of the acid Bessemer converter and basic open-hearth, is apparently now

becoming fashionable. Aside from commercial considerations which we need not discuss at present, its metallurgical rationale is twofold—the increased output over the straight open-hearth process and the simplification of the conditions with which the composition of the pig iron has to comply, rendering possible a greater leeway in blast-furnace working. Granting these advantages, we are forced to ask: Is not the combination of converter and open-hearth already out of date? Could not all the advantages, and others besides, be obtained from a combination of converter and electric furnace or from a combination of open-hearth and electric furnace? Is not the combination of an oxidizing furnace with a furnace of neutral or reducing atmosphere inherently superior to a combination of two oxidizing furnaces? Is the combination of converter and electric furnace not cheaper than the combination of converter and open hearth? These are pertinent questions which require an answer. We have formulated them here to elicit thought and discussion. For the subject is important and of live interest.

### A New Process for the Fixation of Atmospheric Nitrogen.

Atmospheric air is a mechanical mixture (as distinguished from a chemical compound) of oxygen and nitrogen gases—that is, the nitrogen in the air is in elementary form, mixed, but not combined with other elements. The importance of the problem of the "fixation" of atmospheric nitrogen rests in the fact that elementary nitrogen, as contained in the air, is inert and practically useless, while nitrogen compounds are of great commercial and industrial value, especially in the fertilizer industry. The object of the fixation of atmospheric nitrogen is simply to change the elementary nitrogen of the air into a useful nitrogen compound. Since there are various useful nitrogen compounds there are various fixation processes possible. The simplest in idea is to take the oxygen and nitrogen in the air, as it is, and to try and combine as large a portion of them as possible directly into nitrogen oxides (to "burn the atmospheric nitrogen") and then work them up into nitric acid or nitrates. This can be done by subjecting atmospheric air to a very high temperature by means of electric arc discharges, as is done with commercial success in Norway in the process of Birkeland & Eyde and in the Schoenherr process of the Badische Company. The disadvantages of this method are twofold: The first product of the reaction is a dilute mixture of nitrogen oxides in atmospheric air and its transformation into nitric acid is complicated and not inexpensive; and secondly, the electric power consumption is high and the process is commercially practical only in countries where electric power is exceptionally cheap and where there is little incentive to use the available cheap power for other purposes. Norway is the classical example of such countries. Another useful nitrogen compound is calcium cyanamide, which may be used either directly as fertilizer or as starting material for the manufacture of other chemicals, like cyanide. In the manufacture of calcium cyanamide the air cannot be directly used, but it is first necessary to separate the nitrogen from the oxygen in the air (for instance, by fractional distillation of liquid air); the nitrogen is then made to react with calcium carbide at an elevated temperature, yielding directly cyanamide. The power consumption is not so high as in the nitric acid process mentioned above. Never-

theless, the production of calcium cyanamide, being based on calcium carbide manufacture, also requires comparatively cheap power.

\* \* \*

A third process has just been heard of from Europe. Its object is the synthesis of ammonia from nitrogen and hydrogen. There is a considerable margin between the selling price of ammonia and the cost of making nitrogen gas and hydrogen gas on a large scale. But it has always been thought that such a synthetic process was impractical, because the nitrogen and hydrogen gases would be too slow to react. This prevailing idea has now been disproved by Prof. Fritz Haber, of the Institute of Technology, of Karlsruhe, who jointly with Dr. R. Le Rossignol has developed an apparatus for producing in the laboratory 90 grams of liquid ammonia per hour; this apparatus has been in continuous operation for a sufficiently long time to prove its practicability. The essential feature of the process is the use of a high pressure—something like 200 atmospheres—and the use of either osmium or uranium as catalytic agent. It seems that no high temperature is required or desirable, since the inventors mention in one of their experiments a temperature of 500° C. We hope to give further details in the near future. The use of such high pressures as 200 atmospheres would be a novelty in large-scale chemical operations, but seems hardly a prohibitive drawback. On the other hand, the process does not seem to require particularly cheap power. The development of the process decidedly deserves watching. It has already passed out of the laboratory stage, having been taken up by the Badische Company.

### The Raw Materials for Basic Open-Hearth Steel Manufacture.

The statistics of basic open-hearth steel manufacture in the United States in 1909 have been awaited with unusual interest, for the pig-iron statistics, made public Feb. 1, showed a large increase in basic pig-iron production over the best previous record and the question was then presented: Did the production of basic open-hearth steel increase in corresponding ratio, or was a portion of the increased pig-iron production due to a relative diminution in the supply of scrap? Some statistics merely confirm views derived from observation of current events or from a comparison of previous statistics; others furnish direct information as to what is occurring. Of the former class are the statistics of Bessemer steel production, for given the Bessemer pig-iron statistics for 1909 it was possible by comparison with previous achievements to estimate the production of Bessemer steel, and the statistics subsequently compiled showed such estimates to be in error by but a fraction of 1 per cent. Of the latter class are the open-hearth steel statistics. The basic pig-iron statistics furnish no guide to steel production, for the percentage of pig iron to steel has varied widely. The open-hearth statistics for 1909 have been made public the past week by the American Iron and Steel Association. In 1896 for the first time separate statistics were compiled of basic pig iron and basic open-hearth steel production. In the table below we give the statistics from that year to the present, and compute the percentage of pig iron to steel. Both commodities are expressed in gross tons of 2240 tons. A very limited tonnage of charcoal pig iron, occasionally used for basic open-hearth steel

manufacture, is excluded. The steel statistics refer to ingots and castings.

	Basic steel.	Basic pig iron.	Percentage, pig iron to steel.
1896	776,256	336,403	43.3
1897	1,056,043	556,291	52.7
1898	1,569,412	785,444	50.1
1899	2,080,426	985,033	47.4
1900	2,545,091	1,072,376	42.1
1901	3,618,993	1,448,850	40.0
1902	4,496,533	2,038,590	45.2
1903	4,734,913	2,040,726	43.0
1904	5,106,367	2,483,104	48.6
1905	7,815,728	4,105,179	52.5
1906	9,658,760	5,018,674	52.0
1907	10,279,315	5,375,219	52.3
1908	7,140,425	4,010,144	56.2
1909	13,417,472	8,250,225	61.5

One must carefully avoid the inference that the percentages shown above are in the least sense representative of average practice. There is no such thing as average practice. Even in the straight pig and scrap process in the early years there were variations in the percentage at different works, and at the same works at different times, according to market conditions affecting the supply and price of scrap. Then there were even at the start variations between works, one being attached to a Bessemer plant and, therefore, readily supplied with new Bessemer scrap, while another was not so attached. Even such a purely commercial transaction as the formation of the United States Steel Corporation affected the consumption of scrap, for some of the Bessemer works combined had hitherto used their scrap to cool the heat in the converter, but thereafter were made to ship this scrap to allied open-hearth plants. Again, the rise of the Monell and Talbot processes, and later the duplex process, introduced the manufacture of large tonnages of basic open-hearth steel in the manufacture of which little or no scrap was used. Finally, minor variations are introduced by the fact that basic pig iron is used, in a limited way, for other purposes than the production of basic open-hearth steel, and the stocks of basic pig iron at the beginning and end of a year are not identical. Thus the percentages shown in the above table are merely composites. They show nothing as to the practice at a given class of plants, but they do show, in a measure, relations between the classes. It is distinctly the case that the vogue of the different processes of open-hearth steel manufacture depends very largely upon the supply of scrap, and as the increment through the use of ore is small in any case, the relation between pig iron and steel furnishes a valuable index to the necessity of using the various non-scrap processes.

The figures for 1896 and 1897 show a wide variation, increasing from 43.3 to 52.7 per cent, and at this late date do not merit discussion. In general, we may observe that in the late nineties the proportion of pig iron to steel was about 50 per cent, this decreasing to 40 per cent in 1901. We may surmise that the chief factor was that in the late nineties Alabama pig iron was in poor demand, and found its way to Northern steel works, even at Pittsburgh, whereas the more prosperous times which followed, making the choice between Northern pig iron and scrap, reduced the proportion of pig iron used. From 1901, with 40 per cent, there has been a large and almost steady in-

crease in the pig-iron proportion, to 61.5 per cent last year. The most impressive increase was from 52.3 per cent in 1907 to 61.5 per cent in 1909, since the off-year 1908 is naturally not to be taken so seriously as years of full employment. This recent large increase in the percentage of pig iron to steel represents chiefly the growth of the special non-scrap processes. It is probable that the straight pig and scrap plants use substantially as much scrap as they ever did, but whereas they once occupied the entire field, they now occupy but a portion of it. Again, these statistics of production of ingots and castings, while generally regarded as "the steel statistics" because there are no other, are not really statistics of production, but are rather merely the records of the ingot scales. The Bessemer converter removes the impurities of pig iron, but when the ingot is converted into finished product, nearly all the waste goes, not back to the Bessemer converter, but to the basic open-hearth furnace, and in due course the material is weighed over the ingot scale at the basic open-hearth furnace. The Bessemer process weighs only the material it has refined from pig iron, but the open-hearth process weighs the material it has refined from pig iron, and also most of the waste material which the Bessemer process has refined. Thus, in a sense, it obtains undue credit in the statistics.

It is really of minor consequence whether the decreased use of scrap is at all plants, or is merely a pulling down of the general average by the rise of processes which do not use scrap. The point is, that taking the industry as a whole, it uses less scrap and more pig iron, in proportion to its total output, the commercial conditions modifying the process, rather than the reverse. The market price of scrap, relative to the market price of pig iron, has increased very materially in the past two years, showing which is the governing element, for otherwise the use of non-scrap processes would have depreciated the market value of scrap relative to pig iron. There are three chief influences decreasing the supply of scrap relative to the total production of the basic open-hearth steel process: (1) The increase in basic open-hearth steel manufacture has been much more rapid than the general expansion in the iron and steel industry, the former consuming scrap, the latter involving the production of it, whether new scrap or old scrap; (2) the Bessemer steel process, which up to 1907 was growing less rapidly than the open-hearth process, is now actually decadent, and furnishes less new Bessemer scrap; (3) the trend of late in finished steel products has been that of rapid increase in the demand for the light lines, such as sheets, tin plates, wire, pipe and merchant mill products, including hoops, bands and merchant bars, with a smaller increase in demand for the heavy materials, plates, shapes and rails. In the manufacture of these light lines scrap is produced, it is true, but when put into consumption they do not replace so much old material as, on the whole, do rails, plates and shapes. Furthermore, they do not return as old material in as large tonnage as do the heavy sections. Usually there is little left of wire, sheets and pipe after they have served their period of usefulness in their original form. Evidently the basic open-hearth steel industry of the future must depend chiefly upon the refining of pig iron, perhaps with the use of ore, and with such scrap as arises in the rolling of the ingots it produces.



### American Chemical Society.

As already noticed in these columns, the forty-second meeting of the American Chemical Society will be held in San Francisco from July 12 to 15.

The Atchison, Topeka and Santa Fé Railway system has been designated as the official route. The official train will be run from Chicago to San Francisco via Colorado Springs, Grand Canyon of Arizona, Redlands, Riverside, Los Angeles and Santa Barbara, stopping at Adamans for a trip to the petrified forest, and at Lang for a visit to the borax mines. This train will leave Chicago on July 4 and arrive at San Francisco early in the morning of July 12.

The plans of the local committee at San Francisco indicate that the entertainment feature of the meeting will be one of the greatest in the history of the society.

Dr. Wilder D. Bancroft is the president of the American Chemical Society, and Dr. Charles L. Parsons, Durham, N. H., is secretary.

### American Institute of Chemical Engineers.

The summer meeting of the American Institute of Chemical Engineers will be held at Niagara Falls from June 22 to 25. All the sessions will be held at the Clifton Hotel, Niagara Falls, Canada.

On Wednesday, June 22, the meeting will be opened with a business session, at which the reports of officers, council and committees will be presented. The program of papers is as follows:

Wednesday morning, June 22, 11 a. m.—“Changes in Industrial Chemistry Caused by Electricity,” by Edward R. Taylor. “Notes on the corrosion of iron and steel and its prevention,” G. W. Thompson. “Vacuum Distilling Apparatus,” Philip B. Sadtler.

Wednesday evening, June 22, 7.30.—Address of the president, Dr. Charles F. McKenna, “The Study of Materials as an Element in a Course of Chemical Engineering.” Report of the committee on chemical engineering education, F. W. Frerichs. “A New Product for Use in the Arts,” E. G. Wiechmann.

Friday morning session, 9.30.—“Chemical Industries of Canada,” J. A. DeCew. “The Manufacture and Industrial Application of Ozone,” Oscar Linder. “Problems in Chemical Industry,” J. T. Baker. “Arrangement of Filter Presses for Bleaching Oils with Fuller’s Earth,” David Wesson. “Commercial Manipulation of Refractory Elements for Incandescent Lamp Purposes,” Ralph E. Myers.

Friday evening session, 7.30.—“Underground Waters for Manufacturing Purposes,” W. M. Booth. “Loss in Coal Due to Storage,” A. Bement. “Nitric and Mixed Acids,” Schuyler Frazier. “Plant Design,” W. M. Grosvenor.

A great many excursions and visits have been arranged as follows: For Wednesday afternoon a visit to the Ontario Power Company or to the International Paper Company (paper and pulp mill). For Thursday, Lackawanna Steel Company, H. W. Dopp Company plant, Linde Company liquid-air plant, Buffalo Foundry & Machine Company, Larkin Soap Company. For Friday afternoon, International Acheson Graphite Company and Hooker Electrochemical Company. For Saturday, Wickwire Steel Company, Niagara Falls Power Company and Carborundum Works. On Thursday evening a subscription dinner will be held at the Hotel Clifton.

Dr. Charles F. McKenna is the president of the institute, Dr. John C. Olsen, Polytechnic Institute, Brooklyn, is the secretary.

### American Foundrymen’s Association.

As mentioned before in these columns, the convention of the Allied Foundry Associations will be held in Detroit, Mich., from June 6 to 10, 1910. Very complete arrangements are being made

for the entertainment of the visitors, and the usual great success of the conventions of these associations seems assured.

Among the papers to be presented before the American Foundrymen’s Association are the following:

“Foundry Efficiency,” by Benjamin D. Fuller; “The Personal Equation in Accidents,” by Thomas D. West; “Shockless Jarring Machine,” by Wilfred Lewis; “Chemical Standards for Iron Castings”; report of special committee, by Prof. John J. Porter, chairman; “Autogenous Welding of Castings,” by Steelman Stephenson; “The Electric Furnace,” by H. M. Lane; “Overhead Tramrail Systems for the Foundry,” by A. W. Moyer; “The Permanent Mold,” by Edgar A. Custer; report of the committee on industrial education, by P. Krenzpointner; proposed foundry coke specifications, by the secretary, Dr. R. Moldenke.

Among the papers to be presented before the American Brass Founders’ Association are the following: “Cost and Cost System Applied,” by C. R. Stevenson; “Analysis of Lead in Brass Alloys,” by C. P. Karr; “Co-operative Courage in Metallurgy,” by Prof. J. J. Porter; “Electric Furnaces for Melting Non-Ferrous Alloys,” by A. L. Marsh; “Flues in the Brass Foundry,” by Erwin S. Sperry; “Magnesium for Deoxidizing Aluminium Alloys,” by H. M. Lane; “Electric Power Required to Melt Brass, Bronze, Etc.,” by Prof. J. W. Richards; Papers by Dr. F. T. F. Stephenson and Mr. Jesse L. Jones are also promised.

### Bakelite in Germany.

According to a recent issue of the *Chemiker Zeitung* “a new company has been formed in Germany under the auspices of the widely known Rutgers Works to exploit the bakelite patents of Dr. Leo H. Baekeland. The Rutgers Works are naturally deeply interested in the subject as the largest producers of carbolic acid and cresols in continental Europe, since the manufacture of bakelite will open a new and wide field of application for their products. For the start the existing installations are sufficient to manufacture bakelite, so that the new bakelite company will begin to do business shortly.”

Dr. Baekeland may be congratulated on having succeeded in placing the latest child of his inventive genius into such good hands in Germany.

### News from Niagara Falls.

The **National Carbon Company**, the largest manufacturer of carbon products in the world, has for some time realized the importance of being in closer touch with the great electrochemical industries located at Niagara Falls, inasmuch as they nearly all are users more or less of its products. The company has, therefore, decided to locate a large plant at the Falls and equip it with new and improved machinery especially designed to meet the widest range of electrometallurgical and electrochemical requirements.

For several years a large force of experts has been studying the difficult problems of carbon electrode manufacture and the time has now arrived to put into operation the results of their investigations. Although the company has a large plant at Clarksburg, W. Va., devoted exclusively to this work, the constantly increasing use of carbon makes apparent the necessity for still further enlargement of its facilities and Niagara Falls, the very center of electrochemical industries in the United States, seems to be the logical location for the greatest benefit both to the users of its products and to the company itself.

A desirable, well-located piece of property, comprising 13 acres, has been purchased, plans are being prepared and the work of erecting the buildings will soon commence. As now planned it will require an expenditure of nearly a half million dollars for buildings and machinery, and there will be room to double the capacity as requirements demand. It is expected the plant will be ready for operation early next year.



The Norton Company, of Worcester, Mass., and Niagara Falls, N. Y., are about to erect a carborundum plant at Chip-pawa, Ontario (adjacent to Niagara, Ontario). One thousand horse-power will be employed. The plant will be located in a reinforced concrete building 120 ft. x 130 ft.

The United States Heating & Lighting Company are also to erect a large plant at Niagara Falls to take over the work of the National Battery Company, of Buffalo, together with other work.

"Gredag" is the trade name adopted by the International Acheson Graphite Company for its graphite grease in order that it may be distinguished from the inferior grease products which contain impure natural graphite. The graphite blended with a high-grade grease in gredag is the electric furnace product of the Acheson Works. As it is soft and unctuous, this graphite is a perfect lubricant in itself, but in gredag are combined all the merits of both graphite and grease, the combination making a lubricant of high quality and value.

While going to press we learn of a destructive fire on the evening of May 26 at the works of the Hooker Electrochemical Company. The frame buildings, including the cell room, have been destroyed. It will take four months to rebuild them. The damage is estimated at \$400,000.

### A Pathological Museum for Metals and Alloys.

The council of the (British) Institute of Metals announces that there has been established at the offices of the Institute, in London, a pathological museum for specimens of metals and alloys, the first contributions to the museum having been received from the president, Sir Gerard A. Muntz, Bart.

This museum, which is the only one of its kind, ought to be of great service to all interested in the metallurgy of the non-ferrous metals, as it is intended that it shall contain specimens showing the various ways in which such metals as copper, brass, aluminium, etc., can fail either as a result of faulty manufacture or of improper usage.

### Electric Iron Ore Reduction in Sweden.

A contract has been placed by the Electrotekniska Metall Aktiebolaget for electrical machinery of 10,000 hp for electric shaft furnaces for the production of pig iron from ore at Trollhatten, Sweden. This is in addition to the 2500-hp furnace which is being erected at that place by the Jernkontoret.

### The Iron and Steel Market.

May has seen a continuance of the curtailment in pig iron production which began in the latter part of April. Production at the beginning of April was at the rate of about 31,250,000 tons a year, there being a decrease of about 2,000,000 tons in the rate during April, and nearly as large a decrease in May. Most of the May decrease occurred in the early part of the month, and the rate of output is substantially stationary at present.

While a decrease of nearly 4,000,000 tons in the rate of pig iron production in two months or less seems spectacular, it is only about 12 per cent. In about two months at the close of 1907 there was a drop of 50 per cent.

Production of steel ingots and of finished steel products has decreased less than production of pig iron, although there have been some important restrictions at individual steel plants. It is probable that pig iron was being made to excess in February and March.

Business in finished steel products was materially larger in May than in April, and the same was true of pig iron, but in neither quarter was there active buying and the total bookings fell short of production by from 25 per cent to 50 per cent in the different lines. The trend of prices has been distinctly downward in pig iron, and such trend as finished steel prices

have shown have been downward, but the movement has been relatively inconsequential.

In many quarters predictions are made of an upturn in demand and prices in the pig-iron market, based on the assumption that actual cost has been reached in the case of furnaces making pig iron from purchased Lake Superior ore. For the iron and steel industry as a whole, however, a very dull summer is looked for.

The present condition of the iron and steel market is the natural product of well-known factors. The actual ultimate iron and steel requirements of the country increase with great regularity, producing a doubling about once in 10 years. The filling of the requirements, which are more or less flexible at any given time, depends partly upon general conditions, the ease with which loans can be placed, the business and political outlook, etc. These introduce variations in the rate of expressing the requirements. The actual buying is subject to still greater variation, on account of the varying attitude of buyers to the market. If prices promise to advance, they buy more than the mere expression of their requirements would call for; if prices promise to decline, they buy less.

While in the long run productive capacity grows as demand grows, therefore, doubling about once in 10 years, the planning for new erection is done chiefly when the market is strong and active, and as the average project requires from one to two years from original conception to actual production, each period of intense market activity leaves a trail of new capacity. From late in 1904 to late in 1907 there was a strong market, with all productive capacity fully engaged, constituting the longest period of pressure in this business generation. Naturally, the crop of new erections was the largest. Under full pressure in 1907 the country was barely able to reach a rate of pig iron production of 28,000,000 tons a year; the present capacity is between 32,000,000 tons and 33,000,000 tons, and with all present projects completed 34,000,000 tons will be closely approximated.

There has been the normal increase in requirements, since 1907, but that has not been sufficient to employ all of the additional capacity. In 1908 the filling of requirements was held in abeyance as far as possible on account of the artificial maintenance of prices. The break in prices in February, 1909, soon brought buyers into the market with their postponed requirements, and as prices were advancing there was forward buying, price advances and buying interacting on each other to increase both. On the appearance of winter buying decreased, and naturally prices stopped advancing. From a condition in which buying was in excess of actual consumption the market passed to a condition in which buying was less than actual consumption. The actual consumption, there is excellent reason for believing, has been greater this year than last, or, to be more specific, the rate of actual consumption or putting into use of iron and steel in the first five months of this year has been greater than in the last five months of last year. Market conditions, however, have been precisely the reverse, for a strong advancing tendency has given way to a slight declining tendency.

The present situation is that of buyers of coke and pig iron taking hold in a limited way, simply from the belief that in these commodities prices have approximated the bottom, while in finished steel products they are holding off as much as possible, on the assumption that since there has been no noteworthy decline in prices, one is yet to come.

The ease with which demand has grown up to productive capacity, after previous dull periods, has created disappointment at the failure thus far. An adequate explanation is that the increase in capacity has been greater, really much greater, than at previous times because the period of sustained activity which preceded the recent lull was the longest. It will require longer than formerly for demand to grow up to capacity. Indeed, it may, and probably will not, do so for many years, simply because capacity continues to increase even though

present capacity is not under pressure. Apart from the new erection which is based upon existing capacity being strained, there is another class of new erection, of a distinctly competitive character. This class of new erection has been strongly exemplified lately. Large steel interests, finding their profits per ton diminished, have sought new lines of production. One large steel interest has gone into pipe, another is going into wire, and another is going into tin plate and wire. Lake Superior ore interests, finding it difficult to sell ore at the high prices now ruling, are building many merchant furnaces simply to act as channels for the disposal of ore.

Thus it may be several years before existing capacity is strained as it was in the greater part of 1899 and the forepart of 1900, in the latter part of 1901, extending through 1902 into 1903, and from late in 1904 to late in 1907. This does not reflect upon the vitality or growth of demand, but rather upon the freedom in new erection which a series of high-pressure periods has engendered. The industry will likely not find its capacity really strained until a general industrial depression, some time in the future, puts an effective quietus upon new erection and affords time for the country to grow up fully to the capacity. Afterward, as in former cases, actual requirements will probably exceed capacity, and being suddenly expressed will create another boom, such as experienced in 1879 and 1899. Our nomenclature does not regard as "booms" the periods of strong and steady pressure experienced in 1902 and 1905-6-7.

#### Pig Iron.

Pig iron prices continued to decline in the forepart of May, from 50 cents to \$1.50 per ton in different districts and for different grades. In the latter part of May the decline seems to have been arrested, and there has been much larger buying, although there is no regular buying movement, and at the close of the month the rate of buying remains less than either production or actual consumption. Usually, whether in a downward or upward movement, Southern iron finds a level first and it may be doing so in this case. At any rate, our last report noted a decline to \$12, Birmingham, and the observation was made: "At this figure there is the first definite resistance to decline." A month later we may note that pig iron in the valleys has declined 75 cents for foundry, \$1 for basic and \$1.50 for Bessemer, whereas Southern iron is actually selling for second half delivery at the former price of \$12, the only recession being that prompt iron can be picked up at \$11.75, and possibly for iron slightly off the standard at \$11.50. Sales of 5000 tons and 3000 tons of Bessemer have been made at \$16, valley, and of 15,000 tons to 20,000 tons of basic at about \$15, valley. We quote valley prices, 90 cents higher delivered Pittsburgh, as follows: Bessemer, \$16; basic, \$15; No. 2 foundry, \$15 to \$15.25; malleable, \$15.25 to \$15.50; forge, \$14.50 to \$15. Where a range is given the lower price is for moderate-sized lots for early shipment, the higher figure being for small lots or larger lots for extended delivery.

#### Steel.

There has been a general declining tendency, due to light buying and the continued decline in pig iron, but, noteworthy in the general conditions, open-hearth steel has remained relatively scarce and has declined but slightly. Roundly speaking, Bessemer steel has declined \$1.50 in the month and open-hearth 50 cents, prices being quotable, at Pittsburgh, as follows: Bessemer billets, \$25.50 to \$26; sheet bars, \$26.30 to \$27; open-hearth billets, \$28 to \$28.50; sheet bars, \$29 to \$29.50; rods, \$31 to \$32.

#### Finished Products.

Plate prices have yielded fully \$1 a ton, and against \$1.55 for plates and \$1.50 for structural shapes at last report we can report both at \$1.50, with the probability that these prices would be shaded \$1 a ton on attractive business. Black sheet products are being shaded by a few mills \$2 a ton, and galvanized sheet products by \$3 a ton. Merchant steel pipe is un-

changed, the official price being 78 off on full weight, the actual inside price remaining 80 and 5 off for "catch weight"; wrought-iron pipe has declined one point, to an inside price of 75 and 5 off, for full weight, there being little "catch weight" iron pipe made. Steel bars have continued strong, and the agricultural implement interest, which hitherto have obtained concessions from the going market of \$2 to \$3 a ton, on their season contracts, have placed about 200,000 tons for second half and for the full twelvemonth at the full price of \$1.45, Pittsburgh. The refusal to give a concession to this class of buyers is generally interpreted as indicating market strength. An interpretation which is worthy of consideration, however, is along the line that in former years the mills had a definite price understanding and could limit a concession to the class of buyers for whom intended, whereas in the present open-market conditions a concession given to one class might develop into a general break, so that mills have been chary of departing at all from the straight line. Wire nails and plain wire are being shaded \$1 a ton.

Regular prices, f.o.b. Pittsburgh, are as follows:

Standard steel rails, \$28 for Bessemer; \$30 for open-hearth, f.o.b. mill, except Colorado.

Plates, \$1.50 for tank quality, ¼ in. and heavier.

Shapes, \$1.50 for I-beams and channels, 15 in. and under, zees and angles 2 x 3 and larger.

Steel bars, \$1.45, base.

Iron bars, \$1.55, Pittsburgh; \$1.50 to \$1.55, Philadelphia; \$1.50, Chicago.

Wire nails, \$1.85, base; plain wire, \$1.65, base; galvanized barb wire, \$2.15.

Black sheets, 28 gage, \$2.40; galvanized, \$3.50; blue annealed, 10 gage, \$1.75 to \$1.90; painted corrugated roofing, \$1.70; galvanized, \$3.00 per square.

Tin plates, \$3.60 for 100-lb. cokes.

### The Western Metallurgical Field.

#### Deficiency of Present Processes.

The unnecessary status of mining in Colorado and other parts of the West was charged directly to the inefficiency of metallurgy in a paper presented at the May meeting of the Western Association of Technical Chemists and Metallurgists by Mr. A. W. Warwick.

He arraigned metallurgists in the following manner: "Metallurgical work has not kept pace with the operations of the miner. The miners have developed tonnages of ore that must be seen to be appreciated, but which cannot be moved for the simple reason that the metallurgical treatment fails to pay a profit to the miner. Not because the ores lack value, but because the science of metallurgy has been in a stationary condition for years. Metallurgical research work has almost ceased in this Western country. Great deposits of ore and inconceivable tonnage of tailings are unworked, not because of their lack of value, but because of our lack of metallurgical skill. The time has come when these problems must be attacked in all seriousness and they must be solved if the mining industry and, of course that means also the metallurgical industry, is to maintain its prosperity." The statements are, in the main, correct and the conclusions logical. Perhaps not enough credit is given to inventors who are quietly seeking a solution of some of our problems, but on the other hand the problems have multiplied faster than they have been solved, so that at the present time the situation looks unfavorable.

It is true that the easily mined and easily treated oxidized surface ores have largely been treated by the smelting process and the smelting centers have constantly shifted to new fields as fast as the older ones began to yield ores not easily smelted. Instead of improving the smelting process to make it possible to treat economically the more refractory ores, and extract all of their metallic values, the smelter has avoided the problem and moved to more inviting fields. What may be called "by-



product metallurgy" has not been practiced as it must be if the smelting industry is to maintain its footing in the West.

The possibilities of electric-furnace methods of ore treatment were considered by Mr. Warwick as offering some hope for the future of lead and zinc reduction. In matte smelting, also, the electric current should find a possible application. The principal criticism of electric-furnace methods is that the plants are usually of small capacity and the capital invested for the tonnage of ore treated is large. Furthermore, Mr. Warwick believes that, as a rule, metallurgists know very little about electrometallurgical processes, and electrochemists know very little about metallurgy.

In electrolytic methods, however, Mr. Warwick finds hope for the future and even ventures a prophecy that "the problem of treating complex sulphide ores will be most satisfactorily solved by chlorine and electrolysis." While many details of the chlorination of sulphide ores still have to be worked out, it is believed they will be solved satisfactorily and in the Malm process it is hoped a long step in advance will be made toward bringing metallurgy up to the requirements of mining.

#### The Smelter Situation.

The final determination of the principal stockholders of the Modern Smelting & Refining Company to close the company's matte smelter near Denver has occasioned no surprise among those conversant with the situation. The smelter has led a precarious existence ever since it was blown in some months ago and the impossibility of getting ample supplies of ore has led to the final decision to close. Smelting ores in Colorado are a very scarce commodity, and a plant relying wholly on copper as a base for smelting must, under present conditions, have small chances of success. When matte has to be resmelted several times in order to bring it up to shipping grade and also to provide copper for the collection of the gold and silver in successive charges, cost of production must be excessive. It is reported that the present venture has cost its chief supporter some hundred thousand dollars.

In the meantime preparations are going forward for the blowing-in of the matte smelter of the North American Smelter & Mines Company at Golden, near Denver, and of another similar plant, near Alma, Col. It is reported that the Golden smelter has purchased the stock of ore and other supplies now on hand at the Modern plant.

The four smelting plants of the American Smelting & Refining Company, at Denver, Pueblo, Leadville and Durango are running at about half capacity and there is little expectation of any change in these conditions.

In view of what has been said it will be apparent that the constantly recurring reports to the effect that the International Smelting & Refining Company will build a plant in Colorado are nothing but rumors, wholly without foundation. In fact, it can be almost positively stated that such a plant will not be built.

In Utah smelting operations are far more active and the volume of business done much greater than in Colorado. The International Company is rapidly completing its plant for copper smelting at Tooele, Utah. It is expected that ores will be received about June 1 and that the plant will be blown in as soon thereafter as suitable supplies are on hand or are coming in steadily. Reverberatory furnaces will be used exclusively at first, although blast furnaces also may be installed later. In the design of the Tooele plant the International Company has had the benefit of experience gained in the best practice in copper smelting in this country and the new smelter should be successful in every way.

The plant of the American Smelting & Refining Company at Murray, Utah (lead), of the U. S. Smelting, Refining & Mining Company at Midvale, Utah (copper), and of the Garfield Smelting Company at Garfield, Utah (copper), are all in operation.

#### Agriculture and Metallurgy.

The disposition of smelter fumes is quite as live a problem as it ever was, and in Utah and Montana especially the companies

give it considerable attention. The International Company, profiting by the experience of its competitors, is anticipating its day of trouble by placing experts in the field at its new Tooele plant to study conditions in vegetable and animal life before the smelter is blown in. Hitherto many of the litigants against smelting companies have broadly charged all forms of animal and plant disease to the presence of noxious fumes from the smelters. Hence the protective measures of the International Company.

The United States Company at Midvale is removing the  $\text{SO}_2$  from its fumes by means of  $\text{ZnO}$  and by powdered  $\text{CaO}$  injected into the flues. Although the use of the former was at first more extensive and regarded as preferable, it is understood that at present quick lime is more generally used.

Although the Murray plant of the American Smelting & Refining Company is operating under an agreement to reimburse the farmers for smoke damage according to the awards of a board of arbitration, there is considerable dissatisfaction reported among the farmers and it is stated that the Murray plant will be forced to install efficient fume condensing devices to remove the  $\text{SO}_2$  gas.

The suit of the United States Government against the Anaconda Company in Montana to force that company to install fume-condensing equipment is attracting considerable attention. The impression prevails in some quarters that the Government has undertaken a difficult work. Operations at Anaconda are on a scale not duplicated elsewhere in the country, and furthermore the Anaconda Company has made what is probably the most extensive and elaborate scientific investigation into the fume question that has ever been undertaken, and there can be no doubt that if there were a feasible commercial method of handling the fumes at Anaconda the company would gladly install it.

#### Mills.

Negotiations for the sale of the Golden Cycle properties, comprising mines at Cripple Creek, Col., and cyanide mills at Colorado Springs, will hardly be brought to a successful conclusion, in the opinion of the president of the company. An option, expiring June 1, was given to an English syndicate to purchase the Golden Cycle properties, but it has not been exercised. The Golden Cycle mill is probably the most successful cyanide mill in Colorado. It treats Cripple Creek telluride ores from its own mines as well as from others in the same district.

Since the absorption of the Boston Consolidated Company (Utah) by the Utah Copper Company, it is reported that the system of ore grinding used in the Boston Consolidated mill will be altered to conform to that of the Utah Copper mill. At the time these two plants were created, they attracted considerable attention by reason of the fact that such widely different systems of grinding were installed to prepare the same ore for subsequent concentration. The Utah Copper Company introduced graded crushing with rolls and chilian mills to accomplish the same purpose that the Boston Consolidated Company accomplished with Nissen stamps. The tonnage treated by the former system was twice that of the latter, but the percentage recovery of the latter was probably greater than that of the former.

Now that the Utah Copper Company's management controls both mills, it is understood that changes will be made as stated before, so that tonnage will be greatly increased. Some metallurgists regard it as unfortunate that what appears to be purely a commercial consideration should dictate the dismantling of a system which is giving good results from a metallurgical point of view. It has the appearance of sacrificing quality to quantity; of abandoning good metallurgy for immediate financial considerations. If it is true that the Boston Consolidated system effects a better recovery of copper, it would seem to be good metallurgy to continue to use it, but perhaps the demands of business do not always take small refinements into consideration.

### Iron and Steel Institute Meeting.

The forty-first annual meeting of the Iron and Steel Institute was held in London on May 4 and 5.

The president of the Institute for the last three years, Sir Hugh Bell, occupied the chair during the first part of the proceedings. From the report of the Council it may be mentioned that the following gentlemen, representing various nationalities, have been elected honorary vice-presidents: Mr. John Fritz (United States), Dr. F. W. Lürman (Germany), Baron Fernard d'Huart (France), Mr. E. J. Ljungberg (Sweden), and Mr. William Kestronck (Austria).

Dr. Lürman, of Berlin, announced that Sir Hugh Bell had been elected an honorary member of the Verein Deutscher Eisenhüttenleute and presented him with the diploma.

The new president, the Duke of Devonshire, then took the chair. He is the grandson of the seventh Duke of Devonshire who was the first president of the Iron and Steel Institute in 1869. His first official duty was to present the Bessemer medal to Mr. E. H. Saniter.

The Duke of Devonshire then read his presidential address. He reviewed the development of the iron and steel industry since 1869. At that time the four great industrial nations of the world—Great Britain, Germany, the United States, and France—started almost equal, so far as their respective populations were concerned, on the great race for economic superiority. In that year the position of Great Britain in the production of coal, iron and steel was, however, one of absolute supremacy, but that enviable position of superiority was not one which that country could hope to maintain forever.

From 1869 to 1908 the increase of coal production has amounted to 144 per cent in the United Kingdom, 334 per cent in Germany, 1120 per cent in the United States, 170 per cent in France, and 85 per cent in Belgium. In the same time the increase in iron ore production has been 30 per cent in the United Kingdom, 500 per cent in Germany, 550 per cent in the United States, and 300 per cent in France, while the increase in pig iron production has been 66 per cent in the United Kingdom, 740 per cent in Germany, 830 per cent in the United States, and 147 per cent in France, and the increase in steel production 54 per cent in the United Kingdom, 400 per cent in Germany, 233 per cent in the United States, and 285 per cent in France.

The absolute figures of production in 1908 in tons are given as follows:

	United Kingdom.	Germany.	United States.	France.
Coal production.....	261,529,000	148,537,000	415,843,000	36,874,000
Iron ore production....	15,031,000	24,225,000	34,202,000	10,000,000
Pig iron production....	9,957,000	11,805,000	13,936,000	3,412,000
Steel production.....	5,380,000	11,186,000	14,120,000	2,713,000

England can only regain the position of supremacy occupied in 1869 by reckoning in with the United Kingdom the great dominions overseas. "When we compare the production of Great Britain alone with that of Germany or the United States we must necessarily fall short; but when we compare the British Empire and the volume of its trade and manufactures with those of any other competing countries in the world, we need have no fear of the comparison."

The president then took up the social side of the problem, and inquired how far the working classes of Great Britain have benefited by the great changes in industrial and social conditions since 1869. Conditions of work are now safer and more sanitary. Wages are better. Working hours are lighter. Housing is better. A host of improvements in traffic, lighting, education and public assistance have made for the comfort, health and enlightenment of the people. Further, there are free education, old-age pensions, municipal tram services, housing schemes, public libraries, etc. "We may safely say that the working classes of this country at the present day are, on the average, 100 per cent better off than they were when this Institute was founded in 1869."

In the conclusion of his address the president emphasized that to be of service, scientific knowledge must be combined

with practical experience. "There can be, no doubt, recalled by most of you instances of men who have been highly educated in science who in practice were absolute failures—exactly from what cause it is not easy to determine; but it undoubtedly is the case that some men highly trained in science—having left the practical side probably until too late—have upon entering the works failed to properly grasp the situation and apply themselves to the work. Hence the reason that many others who may have been indifferently educated have, by hard plodding and determination, succeeded in occupying the chief position in the country.

"Undoubtedly it is by a combination of theory and practice alone that success can be achieved, and it is to an institute of this nature, with a cosmopolitan membership such as this institute enjoys, that we must look in the future, as we have done in the past, for their guidance and information, without which no industry can hope permanently to prosper."

Mr. S. Selby Bigge, of Newcastle-on-Tyne, then presented a paper on the "development in the production of electric power; its application and bearing upon the iron and steel industries." Mr. E. G. Schemer and Dr. R. Drawe, of Saarbrücken, presented a paper on the "economy and design of modern reversing rolling-mill steam engines." Both papers were discussed together.

A paper by Prof. W. Borchers, of Aachen, Germany, on "the Girod electric furnace" was read at the session of May 5 and discussed at some length. Borchers considers the Girod furnace to be the simplest electric furnace, but this was questioned by those who participated in the discussion.

A paper by Dr. J. O. Arnold and Mr. A. A. Reed on "the chemical and mechanical relations of iron, manganese and carbon" was next read and discussed.

This was followed by a paper of Mr. Edward G. Herbert, of Manchester, on "the cutting properties of tool steels," a paper by Mr. Andrew McWilliam and Mr. Ernest J. Barnes on "some physical properties of 2 per cent chromium steels," and a paper by Mr. Harold Moore on "the A2 point in chromium steel." The latter two papers were discussed together.

The papers by Mr. Sydney A. Gray on case-hardening; by Mr. Adolph Kroll, Jr., on the crystallography of the iron-carbon system; by Mr. C. A. M. Smith on the elastic breakdown of certain steels; by Mr. D. M. Levey on the constitution of cast irons and carbon steels, and by Mr. G. Tagayeff on the homogeneity of metals were read by title.

Abstracts of all these papers together with accounts of the discussions will be given in due course in the Synopsis in this journal.

## CORRESPONDENCE.

### Temperatures in Electric Steel Refining.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—The letter by "M. N.," on page 228 of your April issue, shows an increasing interest in electric-steel melting, even on the part of those engineers who until recently understood little what the electric steel furnace can do and is doing. It must, therefore, be appreciated from this point of view. Its material contents, however, should be modified. Whilst the writer suggests that the reducing atmosphere is the main feature of the electric furnace, it is a well-known fact among all electric steel melters that the high temperature has at least the same important bearing, if not a higher one, upon the refining operation.

I have been present at the same heats referred to in the letter and can say first that the temperature measurements were of only a relative value, that they gave the difference between temperatures observed, but hardly the absolute values of temperature. The Bureau of Standards in Washington writes about the Mesure-Nouel pyrometer used by Professor Richards: "It can hardly be termed a reliable pyrometer. Differ-



ent observers will differ from one another by over 100°, and even the same observer is liable to differ considerably on different days and under different conditions of illumination. It is a little better than the unaided eye." Thus Professor Richards, who was very familiar with his instrument, could tell about the differences in temperature which he observed.

Secondly, when three extremely hot spots, as they are formed by the electric arcs, are distributed over a surface, the temperature of the latter cannot be homogeneous and it is not likely that during the short moment the door of the furnace is open the pyrometer was directed just upon the hottest places, as the arc itself would affect the observation.

Concerning the effect of temperature I refer to a former article in your journal (*Electrochemical and Metallurgical Industry*, 1909, Vol. VII, p. 115) where I indicated in rough lines, both the physical and the chemical effects of high temperatures on the slag as well as on the metal. It should always be kept in mind that the refining of metal underneath a slag is a reaction which mainly occurs along the boundary surface between slag and metal, i.e., what physical chemists call a "heterogeneous reaction." The velocity of it depends on the speed with which the reacting materials are carried from both sides to this boundary surface. Diffusion and mechanical movement contribute to increase this speed and they are themselves increased by heat.

Another class of reaction is going on in both phases (slag and metal as two liquids, not mixed with one another, are each termed a separate "phase"), as, for instance, the reaction of dissolved carbon or carbides on dissolved oxygen or oxides in the metallic phase or the transformation of manganese sulphide into calcium sulphide in the slag phase. These so-called "homogeneous reactions" depend directly upon the temperature. At lower temperatures their velocity is doubled by an increase of 10 centigrades, and at higher temperatures the effect which has not yet been measured, seems to be still more pronounced. I have also shown in the paper mentioned above how the local distribution of temperature in the bath causes the metal to move and need not refer to it again at this place.

To sum up, the high temperature produced right above the metal and the slag yields results that have not been obtained by heating with fuel. And these results are so conspicuous that some people have even supposed the working of some mysterious not yet discovered forces. But there is nothing of that kind. And as the reacting elements are in the main the same as in fuel furnaces aside from the fact that their proportion can be altered so that slag of higher basicity can be employed, the temperature remains as the most important factor for explaining the advantage of the electric furnace, as under its influence the elements can combine and dissociate in a different and quicker way than known before in steel refining.

Chicago, Ill.

RICHARD AMBERG.

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To the Editor of Metallurgical and Chemical Engineering:

SIR:—I am glad that my brief remarks have elicited Dr. Amberg's interesting letter.

What I endeavored to emphasize was that the average temperature of the steel is not very different in the electric furnace and in ordinary oxidizing furnaces. This is proven by the temperature measurements referred to, and to prove this, the relative or comparative temperature indications of the Mesure-Nouel pyrometer are sufficient. It seems to me worth while to point out this fact, as I know there exists a popular erroneous idea that the average temperature in electric steel furnaces is so much higher than in ordinary furnaces.

Dr. Amberg is, of course, correct in emphasizing the great importance of the temperature maxima in the slag, just below the three arcs. I agree with everything he says about the effect of these temperature maxima. But I would emphasize more strongly than he does the possibilities of certain purifying reactions in the electric furnace, due to its neutral or reducing

atmosphere, which could not occur in the oxidizing atmosphere of the open hearth.

In other words, while Dr. Amberg is right to point out the possibility of using a slag of higher basicity, because it can be kept liquid at the higher temperature under the arcs, yet in this respect electric refining is only quantitatively different from refining in the open hearth, and this does not exhaust the possibilities of the electric steel furnace as in it the reactions can be made qualitatively different from the reactions in the open hearth. I refer especially to the removal of sulphur as calcium sulphide in the electric furnace (which reaction would be impossible in an oxidizing atmosphere, since the calcium sulphide would be changed to sulphate, which would react with iron, and the iron sulphate would pass back into the metal bath) and to the removal of phosphorus as phosphide (which would also be impossible in an oxidizing atmosphere).

Of course, these reactions are strongly accelerated by high temperature. That a high temperature is required is indicated by the fact that the formation of calcium carbide seems to play a part in the removal of the sulphur as calcium sulphide, and we know that the formation temperature of calcium carbide is quite high. It is, of course, of fundamental importance that the zone of maximum temperature is produced just where it is needed—in the slag below the three arcs.

Chicago, Ill.

M. N.

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#### Estimation of Water in Petroleum.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—In your May number, on page 283, under the heading "Estimation of Water in Petroleum," a method is mentioned that the writer developed nine years ago in Melbourne, Australia, and described in an article to the Victorian Society of Chemical Industry.

Subsequently, at the request of Prof. Orme Masson, of the Melbourne University, and Mr. Hake, chief inspector of explosives, such an apparatus was installed by me in the Melbourne University for general use and in the Government Laboratory for the estimation of moisture in cordite, etc., and the chemists there were shown its use.

I did a very great deal of work and found the apparatus very useful for all sorts of substances, providing a very positive way of estimating moisture.

An extract from a letter but recently received from Professor Masson may be of interest.

"It may interest you to hear that the use of calcium carbide for determining moisture, which you were the first to describe and which was applied by Dupré four years later to the analysis of cordite, has been much in evidence here lately. There has been a rather important conference between representatives of the Pastoralists and the Shearers on the question of shearing wet sheep, and it becomes necessary to make an extended series of observations of the amounts of moisture in wool.

"The method adopted was essentially yours, though modified in detail, and (as chairman of the Scientific Advisory Committee) I know it has proved of great use. One of my students has also been using the method in a different research, which will shortly be published in one of the English journals, and he will, of course, refer to you."

As I gave the method out free to all, without let or hindrance, the principle of "Honor to whom honor is due" should at least give me the credit by the use of my name whenever the work done by me proves valuable to the user.

Clarksburg, W. Va.

HAROLD A. DANNE.

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#### Blast Furnace Operation.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—In Mr. E. B. Cook's excellent article on "Causes of Non-Uniformity of Blast-Furnace Operation" in your May issue is a statement that I wish to challenge. He says, "as a proof of dry blast's help in preventing this trouble, it is noticed that

the dry-blast furnaces last year surpassed all other furnaces in average work." But I have yet to find the record of a furnace that has been doing better work than our East furnace during the past nine months. For the six months ending March 31, 1910, the average coke per ton of pig (2268 lb.) was only 1977 lb. This figure is based on railroad weights of coke delivered into the coke chutes, and on the tons of merchantable iron made.

The furnace has been on basic iron for the past nine months and has been in blast since July 15, 1908. There has been no serious trouble during this blast except the breaking of the bell rod and the losing of the main bell in June, 1909, when the blast was off for about 48 hours.

The furnace is 75 x 18 x 12 and has eight 5½-in. tuyeres. The blast temperature is carried evenly by blowing through two stoves, and the average temperature is about 1100°.

The average silicon in the pig iron for the six months was 0.75 per cent, and the average sulphur 0.029 per cent. The theoretical yield of the mixture was 55.06 per cent (based on 94 per cent iron in the pig iron) and the actual yield was 54.04 per cent, making the loss in yield only 1.02 per cent. This low loss for flue dust and all other wastes is very low for the 70 per cent of Mesabi ores in the mixture, and shows that the furnace worked regularly. Of course, there were slips, but on the whole the furnace ran smoothly.

The average limestone per ton of pig was 878 lb. The total tonnage of pig (merchantable basic) for the six months was 49,420, or 271½ tons per day. The very severe winter weather in January and February cut down the tonnage and also ran up the fuel consumption to 2029 lb. and 2054 lb., respectively.

The best month's work was 9000 tons, made in December, on 1906 lb. of coke per ton of pig. The loss in yield was only 0.30 per cent, with a 55.34 per cent theoretical mixture.

Have the dry-blast furnaces done better than this?

Mr. Cook's suggestion about blast-furnace managers meeting together to discuss furnace practice is a good one, and it is likely that a practical plan for such meetings of the managers and superintendents of merchant furnaces would be readily adopted. Lately the superintendents of many Ohio furnaces have been exchanging visits with mutual benefit.

*The Columbus Iron & Steel Company.* R. H. SWEETSER,  
Columbus, Ohio.

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*To the Editor of Metallurgical and Chemical Engineering:*

SIR:—The writer was much interested in reading the article in your May issue by Edward B. Cook on the causes of non-uniformity of blast-furnace operation.

In this picture of a blast-furnace man's troubles, much stress is laid on furnace lines and accumulations on the bosh, but the author does not mention one of the most important causes of bosh accumulations, and that is the construction of the furnace.

To make this point clear, it may be stated that there are two methods in general use by blast-furnace engineers for protecting the walls of a blast furnace. This protection is especially necessary in that part of the furnace containing the melting zone—that is, from the tuyeres to the top of the bosh, and it is in this part of the furnace that Mr. Cook states most of the trouble of "building up" occurs.

The two systems of wall protection may be described as the internal and external system.

*Internal Cooling.*—In the internal method, water-cooled plates of cast iron with enclosed wrought-iron pipes, or hollow cast-bronze or copper plates through which water circulates, are laid in the brick walls of the furnace at intervals of from 12 in. to 30 in., depending upon the degree of cooling thought necessary. One practice is to lay the plates flush with the inside of the wall; another to set them back to give a cover of brickwork 4½ in. thick, which is often increased to 13½ in. where less cooling effect is desired.

The purpose of this cooling is to hold the furnace to its

original shape, by maintaining the thickness of the walls. The results with this system, as far as protection to the walls is concerned, is very satisfactory and the thickness is maintained very well where these water-cooled rings are placed. In between these plates, however, the brickwork burns away, forming recesses where the building up takes place, referred to by Mr. Cook, and the cooling plates form shelves that assist the accumulation by furnishing a support.

When a furnace is blown out after being operated with a bosh wall protected by the internal cooling system, these plates may be seen in most instances entirely bare of any brickwork covering and like a series of annular shelves protruding from the wall. That these plates are frequently bare of any brickwork, the writer has also ascertained by cutting into the bosh wall of a furnace that was temporarily shut down for the purpose of replacing some of these cooling plates that had been leaking.

*External Cooling.*—With the external method of cooling, a much thinner brick wall is built for the furnace wall at the start, and this is protected by a plate-steel jacket on the outside, cooled with a water spray, the drippings falling into a water-trough at the base of the steel jacket. The cooling is, therefore, practically uniform over the surface of this jacket and hence over the wall. There is, therefore, no projections formed on the inside of the furnace to act as shelves or pockets for holding material to be discharged at irregular intervals with disastrous results to the temperature of the furnace hearth and to the furnace working.

*Cooling Above the Melting Zone.*—This method of external cooling with thin walls has been in use in Germany for a number of years, for that part of the furnace called the "inwall"—that is, from the top of the bosh to the tunnel head.

During the past year two furnaces have been built in this country with thin inwalls and external cooling and so far the results have been very satisfactory. The most common form of cooling for the furnace wall above the melting zone, however, is the internal system, where any cooling is used or thought necessary. The external cooling with thin walls is, therefore, experimental when used in the upper part of the furnace wall, but it is the older practice for the protection of the bosh wall of the furnace below the bosh line.

*How to Build a Furnace.*—The statement made by Mr. Cook that "No one knows how to build a furnace right" needs some qualification. He cannot mean that no successful furnaces are built, for if that were true, how could any money be made in the iron business?

The condition of furnace construction to-day is the result of very rapid development and improvement in the past 25 years in the direction of increasing the output per stack and reducing the labor costs of operation, but, with that development, new problems of construction have arisen.

These problems vary with local conditions—that is, the ores, fuels and fluxes in use; hence, a construction that may be right for one locality may not give the best results in another. In the same way the management of a furnace must be adapted to local conditions, to the furnace actually in use, the kind of labor available, and the materials on hand for use.

What we can join with Mr. Cook in stating is that the ideal blast furnace has not been built, but it is the goal toward which all blast-furnace engineers and managers are striving and the writer believes much progress has been made toward that end.

DAVID BAKER.

*Ladd & Baker, Inc., Philadelphia, Pa.*

**Concrete flues** have not proved successful when used in smelters for conducting roaster fumes to the stack. Disintegration of the cement coating first occurs, with subsequent sloughing off in large cakes. This ultimately exposes the iron reinforcement, which rapidly weakens under the attack of the acid gases, and the final collapse is only a question of time.



### A New Resistor Furnace.

By F. A. J. FITZGERALD.

There are certain obvious objections to the use of an arc furnace where it is desired to heat the material charged therein by means of radiation. This has led to the development of a furnace in which the charge in the crucible is heated by radiation from resistance, which in some forms may be described as the sealing of the reaction or melting chamber.<sup>1</sup>

During the last few months some interesting experiments have been carried on with a 150-kw furnace of this type at the plant of the Hohenlohe Werke, in Upper Silesia, Germany. The furnace was used for certain experiments in the production of zinc. Fig. 1 is from a photograph which gives a general view of the furnace while actually working. Fig. 2 is a top view of the furnace after the current has been cut off and the cover removed.

Some careful determinations of the heat losses were made, and from these a good notion of the efficiency of the furnace can be obtained. In one experiment lasting several days a bath of molten pig iron was held at a constant temperature of 1250° C. to 1260° C., and it was found that the rate of generation of energy necessary for this was 33 kw. If, then, the furnace is worked at 150 kw and a temperature of 1250° C. maintained, its efficiency would be 78 per cent.

In another experiment, lasting 12 hours, the temperature of the bath was maintained at 1400° C. to 1450° C. with a rate of generation of energy amounting to 42 kw. Therefore, working at full load and at this temperature the efficiency would be 74 per cent.

This last determination is not so accurate as the first for the furnace had not reached a steady condition. This was found out by taking the temperature of the walls, which showed that during 12 hours the wall temperature had increased more than 100° C. and was still rising. If the experiment had been carried on until the temperature of the walls was constant the rate of generating energy would have been less than that actually determined, and consequently the efficiency would have been greater than 74 per cent.

In certain forms of electric furnaces it is possible nearly to eliminate the loss of electrically generated heat by surrounding the furnace with an envelope of burning gas. In a modification of the type of furnace under consideration this is accomplished by building the furnace with double walls, bottom and cover, between the inner and outer parts burning fuel

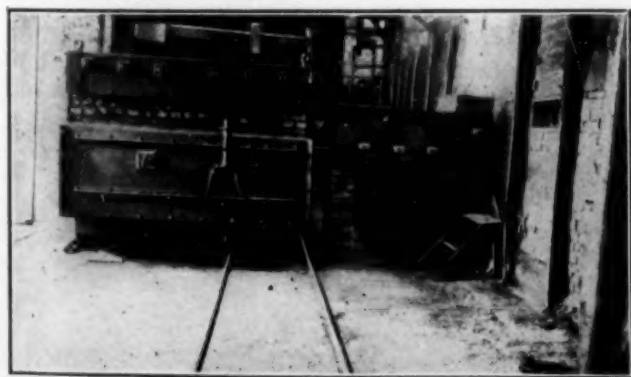


FIG. 1.—ELECTRIC ZINC FURNACE.

which keeps the temperature there the same, or nearly the same, as that in the working chamber.

In this way there is no leakage of heat from the working chamber to the surroundings, consequently all the electrically generated heat is employed in doing useful work. Extended

<sup>1</sup> See review of Patents by John Thomson and F. A. J. Fitzgerald, *Metallurgical & Chemical Engineering*, May, 1910, p. 289.

experiments embodying this principle, and made on furnaces of large size, have shown that it introduces very great economies.

The useful life of a resistance furnace of this type is found to be of satisfactory duration. Although the longest continuous run of the furnace shown in the illustration was only 21 days, this was because it was necessary to shut down in order to make changes in construction which had nothing to do with the construction of the furnace itself.

Other furnaces of a similar type have been run continuously for nearly two months, and there is no reason why such a furnace could not run continuously for several months. Again,

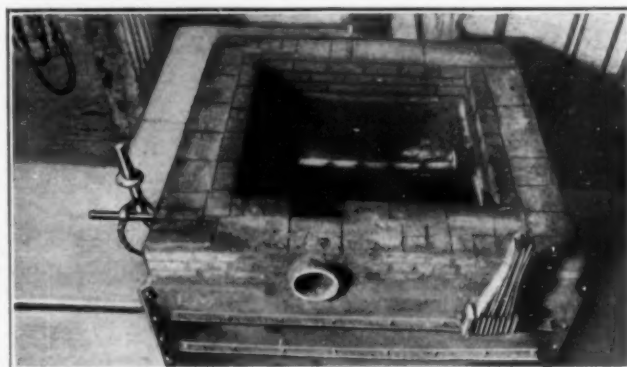


FIG. 2.—FURNACE OPEN.

it has been found possible to run these furnaces and let them cool down repeatedly without having to make any repairs.

While the furnace described was specially designed for zinc smelting, experiments have shown that it also has considerable value in several other metallurgical operations.

*FitzGerald and Bennie Laboratories,  
Niagara Falls, N. Y.*

### Blast and Down Draft Sintering.

By REDICK R. MOORE.

The use of the general term "Bessemer roasting," as proposed in *METALLURGICAL AND CHEMICAL ENGINEERING* of May, 1910 (page 222), for the various processes using pressure or partial vacuum to force a blast of air through a mass of sulphides for their desulphurization and agglomeration seems to me to be unwarranted.

In the first place, the use of any man's name for the distinction of a process which he did not invent and with which he had nothing whatever to do is to be deprecated.

In addition, Sir Henry Bessemer was not the original inventor of the process of converting pig iron into steel, which is frequently referred to as the Bessemer process, but only of some of the apparatus used for the operation of the process. As was proven before the U. S. Patent Office in interference proceedings between Bessemer and Wm. Kelly, of Kentucky, in 1857, Kelly had operated the process eight years before Bessemer conceived it, and priority of patent was awarded to Kelly.

The recarburization of the converted metal by Spiegeleisen was invented and patented by Robt. Mushet, and it was this improvement that made the process practicable and valuable.

Mushet in writing of the "so-called Bessemer process" says "its true name is the Martin process."—(*London Engineering*, May 10, 1861).

The earliest reference that I have been able to find of the somewhat analogous process of copper matte converting is in the *American Journal of Mining* of Sept. 1, 1866, in which it is stated that Dr. F. Leclere, of Paris, patented blowing copper to metal by "the injection of air into the metallic bath . . . obtained by melting raw ores."

The first actual operation of the matte converting operation appears to have been done by John Hollway in England in 1878 (*Jour. Soc. of Arts*, Feb. 14, 1879), and it was finally brought to a successful issue by the skill of David and Manhés in 1883.

The processes of desulphurization and agglomeration of fine sulphide ores under discussion are entirely dissimilar to the converting processes in two very essential conditions. Firstly, converting presupposes that the material operated upon is in a molten condition and, secondly, that it is finished or converted to a finished metallic molten product, whereas in the processes we are considering it is essential that the ores or products treated should be in a comparatively finely divided condition at the start and that they shall not be fused in the operation, as otherwise the process is ineffective, as the light blast used will not penetrate a fused mass and the desulphurization will be incomplete.

The fact that the operation is carried on by the fuel contained in the ore itself is beside the point. Other processes which no one would think of calling converting are carried on in the same manner without any extraneous fuel; for example, pyritic smelting, pyrite burning in shelf roasters and copper-iron sulphide ore roasting or calcining in furnaces of the McDougall or Wedge types.

Pyrite smelting is much more analogous to copper matte converting in that a blast of air under pressure is oxidizing a falling shower of molten matte in the furnace stack. Pyrite burning or McDougall calcining is performed by the passing of air over the beds or layers of ore upon the shelves or floors and through the stream of fine ore falling from one shelf or floor to another in the furnace without any extraneous heat, once the operation is started and as long as the ore is supplied to and caused to pass through the hearths—with proper precautions.

The distinctive features of these processes are the character of the products. In roasting the product is understood to be pulverulent and when fuse boxes or their equivalents or strong finishing heat is used the changed products are called "fused ore," or "sintered roast," according to the condition of the products. In pyritic smelting the products are matte and slag, although practically the same desulphurization as in roasting has been attained. In converting the product is understood to be a refined metallic product, although it may require further refining under certain conditions and the product is always molten. Although the operation may be stopped before a finished product is obtained when some limiting term is employed, such as "converted to white metal," "gas copper finish," etc.

In the Heberlein and other similar processes the distinctive features are the light pressure of the blast used and the condition of the product, which, while not smelted, has been brought to the condition of incipient fusion, and has a honeycombed structure which we call sintered, by the action of a blast of air under pressure through the mass, some portion of which must have been previously brought to a temperature at which the ore would ignite under the conditions maintained.

For this class of processes, it seems to me that the name blast sintering would be appropriate and fully express their character and distinctive action and product.

The product of the Dwight-Lloyd process is somewhat similar to that of the Heberlein, Savelsberg, etc., differing only in that it is in thin layers and more porous, and on that account generally better desulphurized, but the process differs radically in the method of admitting the air and should have a distinct name.

I think down-draft sintering will properly describe and differentiate it from all other processes.

While there are other methods of sintering the distinguishing adjectives herein suggested are at least as readily used as any and are far more descriptive of the process—which is neither converting nor roasting nor a combination of the two, as the terms are ordinarily used by metallurgists.

New York City.

## The New Blast Furnace of the Bethlehem Steel Company—II.

By W. S. LANDIS, M.S.

(Concluded from May issue, p. 231.)

The blast furnaces of this company are grouped on a narrow strip of land running east and west between the old and the new rights of way of the Lehigh Valley Railroad. This strip is just sufficiently wide to accommodate the engine house, ore bins and cast houses of the older furnaces. With the advent of new furnace construction the first large furnace "E" was arranged to run in an east and west direction, contrary to the others.

The furnace "D" being placed between the old and the new furnaces had to be most compactly arranged, as "E" cut it off from extending in any direction but across the narrow strip of property allotted to the blast-furnace division.

This compact arrangement is shown by the general ground plan, Fig. 6.

The ore, stone and coke pockets on the right are the ones

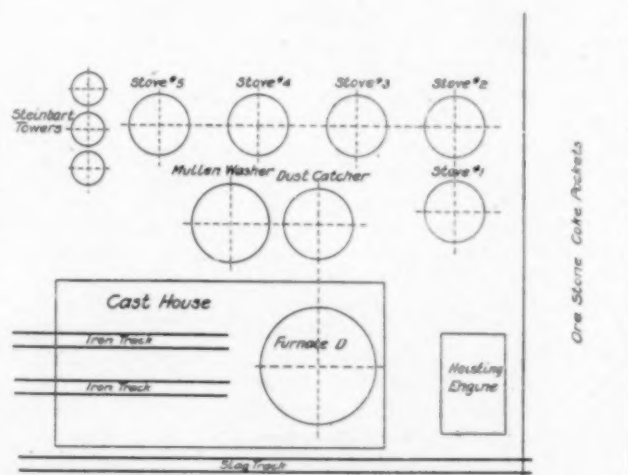


FIG. 6.—GENERAL PLAN OF BLAST FURNACE PLANT.

shown in Fig. 1 of the May issue. The gas-driven blowing engines and dynamos will be placed in a new power house to be erected on the site of the steam shovel in this first photograph.

It is now the intention to electrify all the shops and smaller rolling mills of the immense plant, the power being generated in this new engine house. With the completion of the four large furnaces and this engine house every boiler plant in the works will be dismantled with the exception of the blast-furnace boilers burning from arc gas to supply the steam hammers in the forge shops.

This will require a power generation which will exceed 25,000 hp.

Fig. 7 shows the general lines of the furnace stack. Its principal dimensions are as follows: Height, 90 ft.; diameter of hearth, 15 ft. 6 in.; diameter of top of bosh, 22 ft.; diameter on stock line, 16 ft.; depth of hearth, 8 ft.; height of bosh, 12 ft.; 10 tuyeres, 6 in. in diameter.

The hearth is jacketed with a heavy cast-iron, water-cooled plate extending 6 ft. above and below the center line of the iron notch.

Forty and one-half inches of brick comprise the lining of the hearth.

The bosh walls are 22½ in. thick surrounded by a water box, shown in detail in Fig. 8. A somewhat similar box has been in use on furnace "E" for several years, no trouble having been experienced with this system of cooling so long as care was taken to insure a constant supply of water to it. The inside walls were smooth and regular after blowing out, the ridges



and steps so prominent with plate-cooled boshes being noticeably absent. In one campaign of furnace "E," when through careless attention the water supply was interrupted over one section of the box and a hot spot developed, it was found quite difficult to overcome it as the water when again turned on refused to flow down over the hot plates.

The system of water-cooling employed by Scott in his new furnace bears considerable resemblance to this water-box system which has been in use by the Bethlehem Steel Company for several years.

Above the mantel are placed seven courses of cooling plates 3 ft. apart, 12 plates to the course. A steel wear plate extends downward 12 ft. from just above the stock line.

For charging, the usual inclined bridge carrying balanced

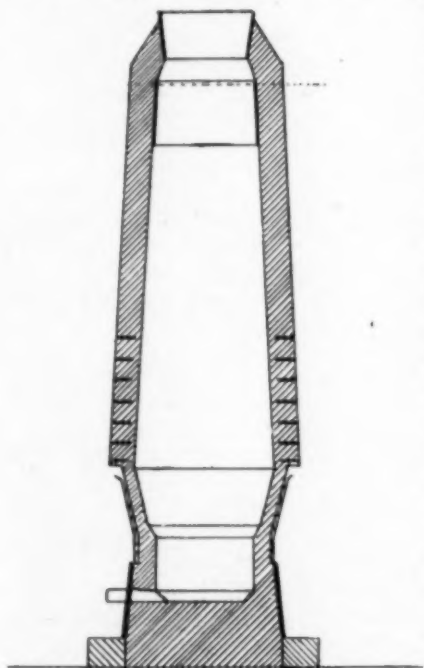


FIG. 7.—GENERAL LINES OF BLAST FURNACE STACK.

skips of 125 cu. ft. capacity is used. A 200-hp motor driving a 6-ft. drum furnishes the power for hoisting. A modified form of the Baker top is used on the furnace, the essential difference being in giving lesser angle between successive positions of the distributor than is found with the ordinary top. In this top considerable lap is given to the distributions.

Several years ago the distributor on furnace "E" gave considerable trouble by refusing to revolve, although the indicator recorded proper distribution.

The result was that the inwall was worn almost through before the trouble was located. It was so far gone that it was either a question of blowing out the furnace or else attempting a repair with the furnace in blast. A patch was decided upon. The furnace was blown down about 40 ft. and 6 ft. to 8 ft. of green sod was rammed in on top of the hot stock as tightly as possible. With this plug in place bricklayers descended 25 ft. down the stack inside and tore out the worn brick, replacing them with new, the work being so skillfully directed that not one was even overcome in the slightest by the furnace gas, though it is true that on account of the great heat the shifts were very short. The furnace ran for several months afterwards on this patch before being blown out. The distributor on "D" has been designed to absolutely avoid any such stoppage of revolution.

The cast house is 56 ft. wide and 111 ft. long. A 25-ton traveling crane serves the casting floor and has its run way extended some 10 ft. beyond the outer end of the house. On a prolongation to the inclined bridge at the top of the furnace is bracketed an overhanging crane with both transverse and longitudinal movement, for serving the top. To enable this crane to reach the ground a panel of the cast-house roof, including a truss, is made removable, a vertical from the crane dropping well in front of the furnace in the cast house to the hot-metal tracks shown in Fig. 6.

The greater portion of the pig iron made by the Bethlehem Steel Company goes direct to the basic steel furnaces, but a smaller portion reaching a casting machine of the Davis type (modified by the steel company to avoid water chilling). The

ladles are brought in on two parallel tracks underneath the floor off the cast house. Six ladles can be accommodated at one time, the flow of metal being regulated by the gates and runners shown in Fig. 3 of the May issue of this journal. The slag track is outside of the cast house, the track being extended sufficiently far back to permit of the storage of a car for the reception of clean-up material, etc., from around the furnace.

The ores used by the company require a high temperature for successful smelting.

To this end five 22 ft. x 100 ft. McClure type hot-blast stoves are in use. To ensure their working at their maximum efficiency for a long period of time a thorough cleaning of the gases had to be assured.

After leaving the furnace the gas passes through a conical dust-catcher 25 ft. in diameter. From this it was originally planned to lead the gases through two Mullen washers in series before going to the stoves.

This arrangement was later modified to include only one 28-ft. Mullen washer and in place of the second to use a series of Steinbart towers.

These towers, three in number, each 12 ft. in diameter and 75 ft. high, are connected in multiple between the Mullen and the stoves.

The essential feature of these washers is the use of a rapidly revolving stream of water falling on a rain-making distributor. This insures a very uniform distribution of drops throughout the whole area of the tower, a test made with buckets set at various places in the bottom of the tower showing practically simultaneous filling of them all. A by-pass to the stoves is provided for the gas in case the washers are out of commission. No valves are used in this distribution of gas around the Steinbart towers; instead, the flow is controlled by the emptying or filling of the siphons shown in Fig. 4 of the last issue. At the present time the towers are not yet in operation; there is no question of their cleaning the gases, but the amount of moisture carried over by the gases might be a serious cause of trouble in the future.

The gas is led from the cleaning system directly to the stoves.

When all five are in commission four are on gas four hours and one is on air one hour. The question has arisen as to whether there is not too liberal stove capacity when all five are working. With 400,000 brick in each stove, the passage of the blast through one for an hour will cause a drop in temperature of over 100° C. (average drop for the whole mass of brick). This is a rather large drop for uniform conditions regarding blast temperature and for minimum wear and tear on stove lining. It

seems that the utilization of one of the stoves as an equalizer would settle the difficulty, certainly much more efficiently than the use of the McCarthy equalizing valve as at present installed in the hot-blast main.

On the whole it is a question if these is another furnace in the country more complete in details and appointments than this one, representative as it is of the \$13,000,000 worth of improvements now under construction at this Eastern steel plant. In conclusion the author extends his most sincere thanks to the general manager, E. G. Grace, for the many courtesies extended during the preparation of this description.

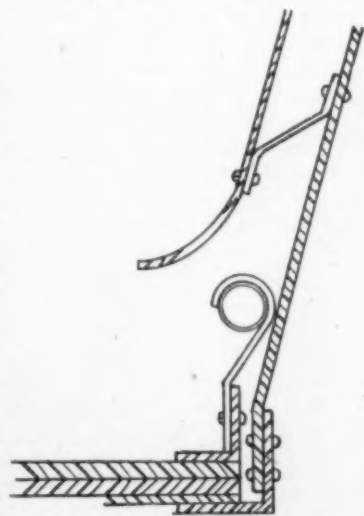
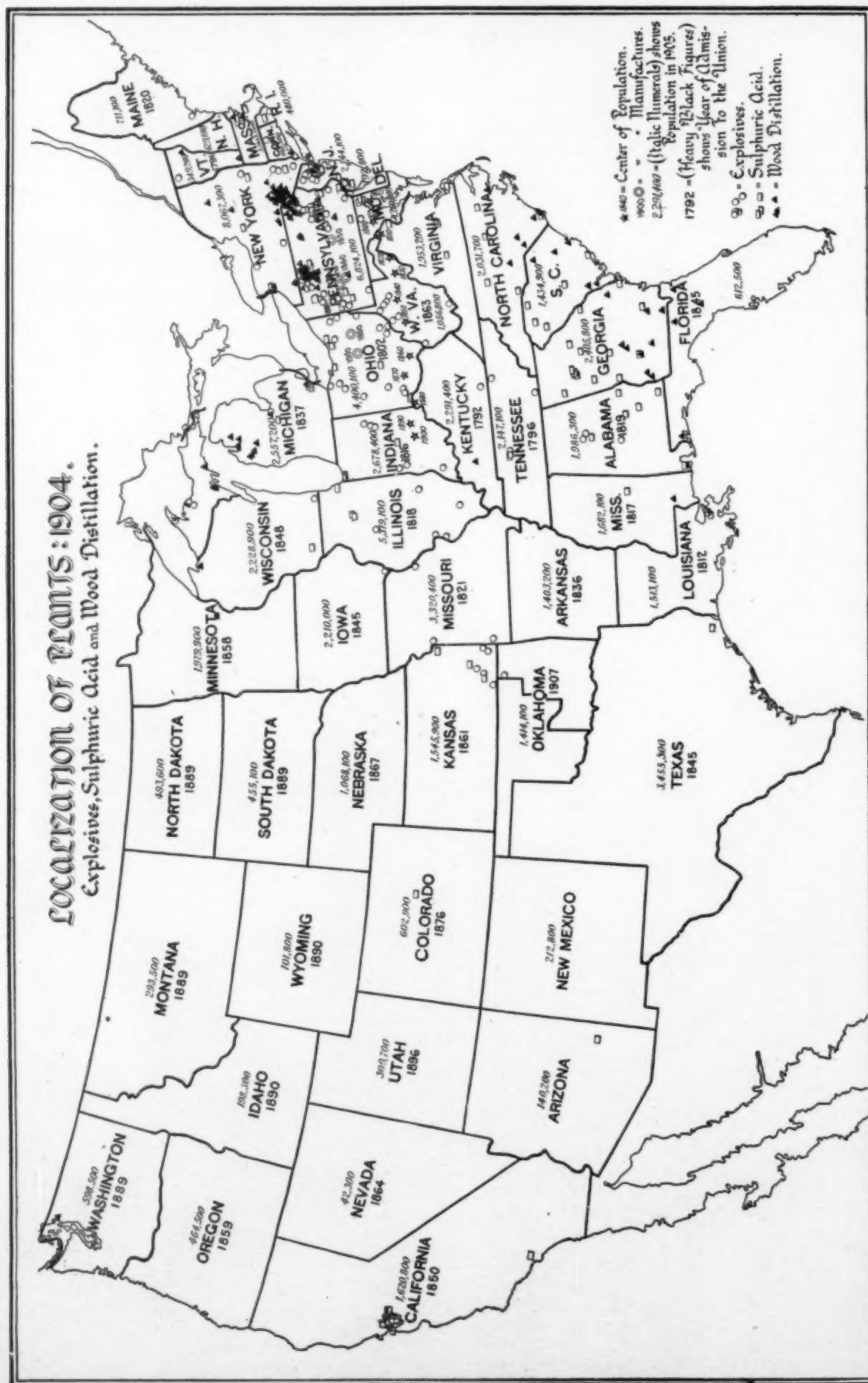


FIG. 8.—DETAILS OF WATER BOX.





### Map of Sulphuric Acid, Explosive, and Wood Distillation Plants in the United States in 1904

In Prof. Charles E. Munroe's address, delivered before the American Institute of Chemical Engineers, on the chemical industries of America, he mentioned (page 269 of our May issue) a map which he had, through the courtesy of the director of the Bureau of Census, had prepared of the United States showing the location of the establishments, both principal and subsidiary, manufacturing sulphuric acid, those making explosives, and those engaged in wood distillation, each being a typical industry, and the sulphuric acid industry being generally accepted as of fundamental importance. This map is now reproduced on page 320, through the courtesy of the American Institute of Chemical Engineers.

From this chart it appears that 13 States and Territories, namely Arkansas, Idaho, Montana, New Mexico, North Dakota, South Dakota, Utah, Iowa, Nebraska, New Hampshire, Nevada, Oregon, and Wyoming, containing 7,648,000 out of the 76,303,387 inhabitants of the continental United States in 1905, or over 10 per cent of the whole, did not possess a single establishment devoted to any one of these industries.

Considering sulphuric acid only, which is so important an industry that it has frequently been referred to as an index of the state of civilization of a people, we find that 23 States and Territories, namely, the 13 just enumerated, together with Delaware, District of Columbia, Kentucky, Maine, Minnesota, Missouri, Oklahoma, Washington and West Virginia, containing 19,562,200 population, or 25.6 per cent of the total, did not possess a single sulphuric acid plant within their borders.

Turning now to the East, we find that 11 out of the 13 original colonies, viz: Connecticut, Georgia, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina and Virginia contained 30,695,000 population, or 40.2 per cent of the total, and 100 sulphuric acid factories, or 67.1 per cent of the total number existing in the country. Analysis of the statistics of the separate States shows that the number of these establishments does not follow the population, Georgia, for instance, with about one-fourth the population of New York, having twice the number of sulphuric acid factories that New York had.

Prof. Munroe remarks that the number of establishments in an industry is an unsafe criterion as to the magnitude or importance of that industry, but this feature has been chosen as lending itself most easily to graphic demonstration. He had, therefore, assembled, by geographic divisions, in Table VII (our May issue, p. 270) data for the quantity of sulphuric acid produced, and inspection of this leads to much the same result as to that which was drawn from the consideration of the distribution of the establishments.

As Dr. Munroe points out, all investigations show that there is an enormous extent of fairly well-populated area in this country yet awaiting development by the chemical engineer.

### Chandler and Raymond Dinners.

On the evening of April 30 two memorable banquets were held, one at the Waldorf-Astoria in New York in honor of Dr. Charles F. Chandler, the other at the Plaza Hotel in honor of Dr. Rossiter W. Raymond. Both were very well attended, very successful, and will long be remembered.

At the Chandler dinner Dr. Schieffelin was the toastmaster. The large bronze bust of the guest of honor was not quite ready, but was presented to Columbia University by Professor Bogert in a graceful speech and accepted by Dr. Butler. The smaller replica was, however, finished and was presented to Mrs. Chandler, who in turn presented it to the Chemists' Club, where it will be one of the features of the new club house.

At the Raymond dinner Dr. James Douglas presided, who presented to Dr. and Mrs. Raymond a magnificent silver service,

while Mr. W. L. Saunders, in a graceful address to Mrs. Raymond, presented her with 47 American Beauty roses, one for each year of her married life.

### An Efficient Laboratory Electric Hot Plate.

The use of the electric hot-plate has contributed greatly to the improved conditions under which the most of the laboratory work of to-day is conducted. It has superseded the old coal-fired hot-bath and the oil or gasoline stove that was formerly so common in smelter laboratories and has provided a means of working under cleanly and comfortable conditions. Where electric power is reasonably cheap, the electric hot-plate can be made very efficient for a large volume of work, and since most of the former objections to its use have been overcome it is growing in use and favor.

High first cost and high expense of operation were originally the objections to the use of the electric hot-plate, and these were multiplied greatly in cases where capacity for a large volume of work was required. But with the decreasing cost of electric power and the ingenuity of the chemist who wants to improve conditions in his laboratory, it is not uncommon to find in use efficient electric hot-plates made at the plant from materials already on hand or easily obtained.

Following is a description of an electric hot-plate in use in the laboratory of the Empire Zinc Company, Canon City, Col. The device as used at present is an evolution from former apparatus that had shown weak spots. The plate is 34 in. x 17 in. and has a thin sheet-iron base on which is a piece of asbestos board  $\frac{1}{4}$  in. thick. This is covered with sheet mica on which rest the heating coils. Above the latter is additional insulation in the shape of sheet mica. Finally, the top, which is of  $\frac{1}{2}$  in. planed cast iron, completes the apparatus. The whole can conveniently be placed on standards of any desired height, and forms a plate about 2 in. thick and of the area given above.

The construction of the heating coils is the interesting feature of this plate. They consist of fire-clay bars with No. 18 German silver wire. Iron rods, wrapped with mica, were tried originally, but proved unsatisfactory. The fire-clay rods now used are made according to a pattern designed for the purpose. They are  $1\frac{5}{8}$  in. long and rather triangular in cross-section. The dimensions of the latter are  $1\frac{1}{4}$  in. x  $\frac{3}{4}$  in., the larger dimension being the base of the triangle and the smaller its height from base to apex. The surfaces of the rods have slight lateral corrugations or grooves to facilitate the winding of the wire and to hold it in place.

The rods are wound in pairs and there are four pairs in the plate. They are laid with their length extending the width of the plates, and are spaced about 4 in. center to center. Four switches are provided, one for each pair of rods—so that different sections of the plate may be used as needed. Each of the end pairs of rods is wrapped with 73 ft. of No. 18 German silver wire, while each of the middle pairs is wrapped with 75 ft. of the same material. For convenience in getting at the coils, the top is made readily removable, being attached to the base by bolts.

The current is taken from the 112-volt, alternating-current lighting circuit, and the power consumed when the four sets of coils are in use is 48 kw.

Records of power consumption have been kept for nearly two years, and while the volume of work done cannot be accurately stated, it is estimated that 2000 chemical determinations are made on a consumption of about 500 kw-hours per month. For the past 10 months the average consumption has been 524 kw-hours.

Considering the efficiency of the apparatus and the cleanliness of the work, the cost of operation compares very favorably with that of the gasoline plate which was formerly used, although, of course, current is actually more expensive. Plenty of heat is available for all analytical purposes, sulphuric acid being readily run to white fumes.

## The Chemical Export Trade of the United States.

By WILLIAM POLLARD DIGBY.

**Introductory.**—Of all manufacturing industries, that of the chemical trade offers a special case for consideration. Its main activity depends upon the prosperity of other manufacturing industries. In their periods of expansion it has to meet increased demands for products to be used in the treatment of their raw materials. Paper mill, wood-pulp factory, textile bleaching or dyeing are among the foremost of the dependent industries, whose numbers and whose respective spheres are yearly extending.

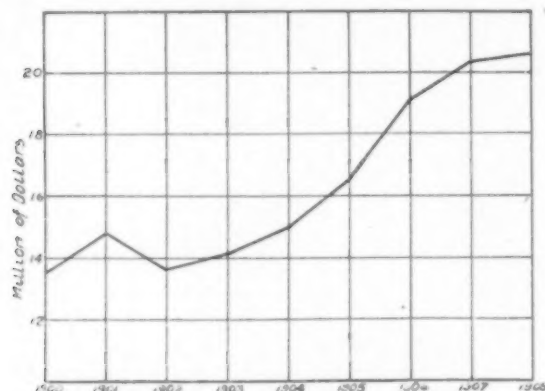


FIG. 1.—TOTAL EXPORT TRADE.

A checking of trade activity due to poor harvests, or to overproduction reacts indirectly upon the maker of alkali or aniline dyes, through the diminished demand for articles of clothing. In this enormous complexity of the interrelation of industrial questions, the phenomenon of the interdependence of manufacturing chemistry with other industries is typical. The trend of motion is, of course, complex, swayed as it is by both economic and technical questions.

On the latter side there is the dependence of certain manufacturing processes upon materials, a demand met either locally or from an external source. In new countries and in the establishment of new industries such demands are almost invariably met by importations. The effects of national fiscal policies tend in favor of the manufacturing of the raw material (actual or contributory, actual in the sense, say, of a material such as cotton yarn requiring bleaching and contributory in the sense of permitting or facilitating a charge in the nature of the actual raw material, such as the "bleach" liquor used in bleaching the yarn) as near as possible to the point of utilization.

Scientific education is now obtainable in many quarters, and the graduate of a good university is fitted for employment in new industries. Then, too, industrial conditions are continually changing, industries migrate just as races migrate, while the progress of scientific invention may displace existing processes just as the ammonia soda process displaced the Le Blanc, only to be threatened in its turn by electrolytic processes.

Under conditions, therefore, economically and technically in a state of flux, this industry both serves as a fair index to the state of trade generally, and also to indicate the amount of industrial progress achieved. As to the state of trade generally, there is the small directly domestic trade for small quantities of such articles as bleaching powder or washing soda for the small house-holder, and the indirectly domestic trade for large quantities of the aforementioned or kindred articles for utilization as contributory raw material.

In the first place, in any new country the directly and indirectly domestic trade are at first incapable of local cultivation despite the imposition of fiscal duties. As the local de-

mand becomes greater the question of whether the contributory raw material can be made locally causes the tentative introduction of its manufacture. Thus, while the output of the finished material may continue to increase, the external purchases of the contributory raw material at first fail to keep pace with the increase and then fall in volume. Despite the fact that science knows no bounds of a racial or national character, all industries, however, cannot bear translation. Sometimes they still flourish in the country which has first adopted them, while their offshoots have failed to take root on transplanting. It is not possible, of course, within the limits of an article of this nature, to plunge deeply into vexed economic questions such as these.

One can merely indicate that these forces are always tending to direct or to deflect the courses of commerce, and point out that they, while subordinate to the swirling tide of supply and demand, in the barter between food producer and food consumer, are not without their marked effect.

**The Chemical Export Trade.**—Taking the ten years ending in 1908, the total export trade of the United States in chemicals, drugs, dyes and medicines has varied from a minimum of \$11,410,000 in 1899 to a maximum of \$20,873,000 in 1908.

The annual fluctuations in the sum total of this trade for each fiscal year up to and including June 30, 1908, are illustrated in Fig. 1. The generic description of chemicals, drugs, dyes and medicines is nebulous; a detailed examination of this heading would obviously be of so much greater value to pharmaceutical chemists than to the engineering and manufacturing readers of this paper, hence drugs and medicines are not considered in this review.

The distribution of individual items, both of general chemical interest and of allied electrometallurgical industries (as distinguished, of course, from purely metallurgical industries, such as iron and steel) is worthy of analytical treatment, for which purpose the world's markets have been roughly divided into six

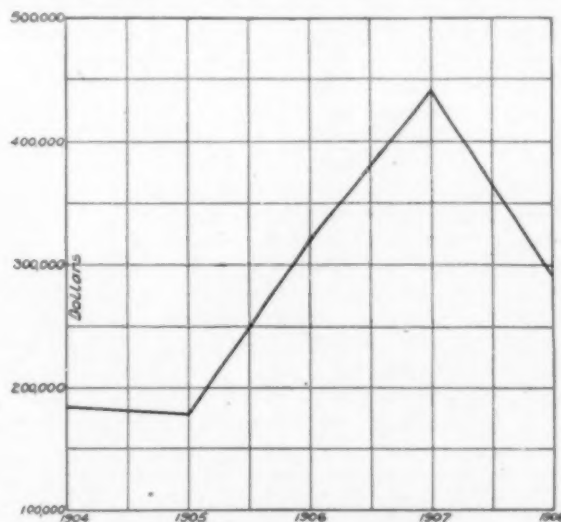


FIG. 2.—EXPORT TRADE IN ALUMINIUM.

zones, viz.: Great Britain, British North America, remainder of British Possessions, Germany, remaining European countries, and South America.

**Wood Alcohol**, for instance, has made large strides, and now in the last year covered by our review was over \$800,000. This is one of the few American chemical exports which only enter Canada to a negligible extent. Indeed, all the indications point to Canada as a future alternative source of supply for the European purchasers. Chief among these is Great Britain, which takes close upon one-half of the American exports.



In 1907 the exports to Germany were about 7 per cent greater than those to the United Kingdom, but in 1908 British purchases had been increased by 30 per cent, and German purchases reduced in almost the same ratio. The demands of the remaining European countries are of a fluctuating nature. Table 1 sets out the distribution during each of the last five years.

TABLE 1.—EXPORTS OF WOOD ALCOHOL.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$335,964	\$362,032	\$259,850	\$343,840	\$451,406
Br. North America..	692	1,607	12	382	133
Germany .....	185,783	209,010	164,754	367,704	241,600
Rest of Europe....	38,849	13,769	32,600	149,118	118,895
British Colonies....	8,872	5,257	5,446	.....	4,334
South America.....	913	80	728	.....	210
Rest of World.....	13,285	11,660	3,077	1,775	3,115

Total ..... \$585,359 \$603,385 \$466,467 \$862,819 \$819,753

The average declared value per gallon exported was as follows:

1904.....	\$0.490
1905.....	0.550
1906.....	0.597
1907.....	0.401
1908.....	0.418

The external trade in pot and pearl ashes is quite small. In 1907 the best of the five years under review, the total value was only \$83,000, of which about one-half went to Canada.

TABLE 2.—EXPORTS OF POT AND PEARL ASHES.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$31,082	\$9,320	\$16,179	\$22,631	\$26,697
Br. North America..	9,013	9,250	30,930	39,634	14,572
Germany .....	.....	13	3,032	5,939	.....
Rest of Europe....	12,926	7,317	9,257	12,853	9,290
British Colonies....	20	724	25	752	851
South America.....	454	383	370	159	546
Rest of World.....	4,305	3,119	1,452	1,383	7,632

Total ..... \$56,800 \$30,156 \$61,245 \$83,350 \$59,588

The trade in acetate of lime is of much larger dimensions. Canadian purchases are negligible. The distribution of these exports is subject to wide fluctuations. British purchases were at their highest value, viz., \$140,736 in 1905, and at their lowest, viz., \$55,676 in 1908. Sales to Germany and the rest of Europe are indicated below.

TABLE 3.—EXPORTS OF ACETATE OF LIME.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$114,290	\$140,736	\$88,002	\$134,869	\$55,676
Brit. No. America..	1,354	.....	14	19	2
Germany .....	294,290	411,956	635,260	719,704	432,850
Rest of Europe....	683,505	676,653	1,221,496	1,560,732	1,027,399
Brit. Colonies....	32	5,026	2,761	3,412	.....
South America.....	.....	.....	.....	.....	.....
Rest of World.....	9,868	10,403	3,300	.....	27,513

Total ..... \$1,103,389 \$1,245,776 \$1,950,833 \$2,418,736 \$1,543,440

The export of crude sulphur is an industry which has made remarkable progress. Not of sufficient magnitude to merit separate enumeration in 1904, the figures given below show a trade increased five fold by the end of 1908.

TABLE 4.—EXPORTS OF SULPHUR.

	1905.	1906.	1907.	1908.
Great Britain .....	\$6,000	\$11,920	\$10,400	\$10,400
British North America.....	.....	194,446	147,456	349,981
Germany .....	\$51,413	91,504	57,750	131,160
Rest of Europe....	81,303	65,558	143,560	263,393
British Colonies .....	.....	.....	.....	.....
South America .....	.....	.....	.....	115
Rest of World.....	.....	40	6,544	29,986

Total ..... \$132,716 \$351,548 \$367,230 \$785,335

The average declared value per ton exported was as follows:

1905.....	\$1.97
1906.....	2.10
1907.....	2.03
1908.....	2.04

The item coal tar is not worth freight to Great Britain or Germany where bituminous coal is plentiful and where gas meets such a large part of the demand for street and house lighting. Exports have mainly gone to Canada and trade having increased from \$14,499 in 1904 to \$148,812 in 1908. Sales to European countries other than Great Britain and Germany have fallen from \$28,395 in 1905 to \$11,715 in 1908.

Lime is mainly supplied to Canada, whose demands have risen from \$35,533 in 1904 to \$82,690 in 1908. The distribution during five years to all other countries are less than \$15,200.

Carbon black, gas black and lamp black have gone mainly

to Great Britain. The trade is mainly European, as shown below:

TABLE 5.—EXPORTS OF CARBON BLACK, GAS BLACK AND LAMP BLACK.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$123,722	\$204,903	\$272,813	\$169,337	\$200,025
British North America..	29,939	33,168	35,914	35,058	24,944
Germany .....	105,498	136,528	164,285	128,718	131,946
Rest of Europe....	73,566	106,992	120,730	112,448	117,672
British Colonies.....	1,236	1,775	1,942	1,684	3,177
South America.....	990	7,347	847	132	153
Rest of World.....	3,062	9,023	27,622	5,638	15,990

Total ..... \$329,013 \$501,736 \$624,153 \$453,015 \$493,907

The exports of oxide of zinc are widely distributed. The British demand seems steady, while that of Germany and Canada are falling. The total distribution to the remaining European countries is fairly steady.

TABLE 6.—EXPORTS OF ZINC OXIDE.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$405,250	\$306,040	\$423,519	\$429,663	\$451,505
Brit. N. America..	52,756	34,777	97,483	54,865	32,460
Germany .....	8,251	45,875	137,965	115,125	107,420
Rest of Europe....	205,444	218,069	450,930	393,614	441,329
British Colonies....	266	115	3,887	252	14,187
South America.....	.....	13	308	.....	.....
Rest of World.....	469	637	780	3,471	3,547

Total ..... \$672,436 \$605,526 \$1,114,872 \$996,990 \$1,050,448

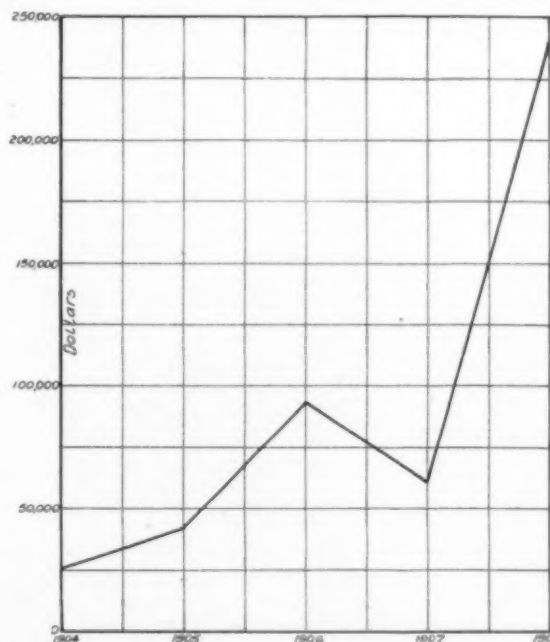


FIG. 3.—EXPORT TRADE OF EMERY AND CORUNDUM.

Prices per pound have varied to the following extent:

1904 .....	\$0.040
1905 .....	0.036
1906 .....	0.037
1907 .....	0.038
1908 .....	0.039

Sulphate of copper is a declining American export. The British and German demands had fallen to zero in 1908, while the Canadian trade in that year reached its lowest value. Of chief importance is the loss of trade to the rest of the Continent of Europe, which in 1908 was almost one-fourth of the value in 1904. The price of this commodity is intimately associated with that of copper; to discuss copper prices and export distribution is beyond the scope of this article.

TABLE 7.—EXPORTS OF COPPER SULPHATE.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$4,231	\$7,559	\$18,529	.....	.....
Brit. N. America..	38,843	39,736	43,523	\$34,342	\$33,650
Germany .....	138,624	159,008	71,872	11,060	.....
Rest of Europe....	799,252	416,879	690,217	267,390	201,783
British Colonies....	.....	6,072	12,893	140	.....
South America.....	36,266	49,628	86,877	77,001	115,047
Rest of World.....	116,470	111,140	111,741	35,977	37,577

Total ..... \$1,133,686 \$790,024 \$1,035,052 \$425,910 \$408,057

While aluminium ought logically to be tabooed along

with copper, this industry is so typical of modern electro-metallurgy that its brief statistical treatment along with other electric-furnace products is justifiable in these columns. In regard to aluminium, the demands of the purchasing countries have been irregular. Thus, British demands were increased nearly three fold in 1908 as compared with 1907, but Canadian trade fell to less than one-fourth. The general distribution is set out in the following table:

TABLE 8.—EXPORTS OF ALUMINIUM.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$18,068	\$9,653	\$27,120	\$47,967	\$124,699
Brit. N. America...	137,334	79,567	192,046	296,546	69,101
Germany .....	1,255	2,980	19,980	5,716	1,739
Rest of Europe.....	4,485	59,822	35,337	8,654	38,311
British Colonies....	6,634	10,649	20,556	32,045	17,632
South America.....	11,169	7,802	8,107	13,068	16,393
Rest of World.....	4,252	5,377	15,385	38,991	22,141
Total .....	\$183,197	\$175,859	\$185,531	\$442,987	\$290,016

Emery and corundum have proved to be exports of increasing importance. The large upward stride in 1908 is most striking. The distribution of exports is given in the following table:

TABLE 9.—EXPORTS OF EMERY AND CORUNDUM.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$5,207	\$3,892	\$13,373	\$4,202	\$51,536
British North America...	1,204	540	1,579	2,998	23,308
Germany .....	115	15,139	38,354	22,767	81,165
Rest of Europe.....	10,008	16,403	35,147	27,744	71,154
British Colonies....	8,144	3,980	4,123	752	4,533
South America.....	259	1,838	413	725	3,324
Rest of World.....	538	647	486	2,699	5,771
Total .....	\$25,475	\$42,446	\$93,475	\$61,887	\$240,791

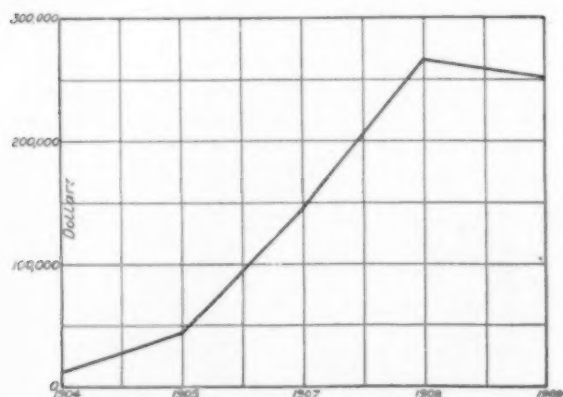


FIG. 4.—EXPORT TRADE IN GRAPHITE.

The export of graphite is an example of the rapid expansion of a promising industry, and nothing could be more gratifying to those concerned than the reflection that an export trade less in value than \$12,500 should in five years have grown to over \$230,000. The distribution during each year is given below:

TABLE 10.—EXPORTS OF GRAPHITE.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$2,448	\$8,338	\$42,264	\$35,384	\$45,159
British North America...	2,264	2,629	2,359	9,374	6,876
Germany .....	4,569	10,188	43,098	93,480	52,222
Rest of Europe.....	2,716	16,340	38,543	74,855	93,888
British Colonies....	121	1,705	5,237	27,532	29,984
South America.....	140	1,804	1,875	3,058	4,711
Rest of World.....	159	3,505	10,337	22,372	16,538
Total .....	\$12,417	\$43,609	\$143,712	\$266,055	\$251,283

The export trade in acids has fluctuated somewhat from a minimum of \$246,000 in 1904 to a maximum of \$368,000 in 1907. As regards distribution, by far the largest market is Canada, which accounts for more than half the exports. A comparatively small trade is carried on with Europe. The distribution each year is as follows:

TABLE 11.—EXPORTS OF ACIDS.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$1,479	\$14,476	\$9,345	\$12,106	\$18,228
Brit. North America...	70,498	79,922	119,081	162,134	64,135
Germany .....	2,767	2,767	2,405	712	69
Rest of Europe.....	2,130	8,190	1,620	2,666	1,648
British Colonies....	28,551	31,659	17,620	9,237	9,856
South America.....	19,567	12,634	20,277	20,711	21,026
Rest of World.....	123,597	315,272	143,474	160,086	214,021
Total .....	\$245,813	\$325,020	\$314,122	\$367,682	\$328,034

Two tables are appended affording an analysis of the above tables which have been divided into two groups, viz: the first including electrochemical products, which included aluminium, carborundum and graphite, and the second group including all others.

ELECTRO-CHEMICAL PRODUCTS.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$25,663	\$21,883	\$82,759	\$87,553	\$221,394
Brit. North America...	140,802	82,730	195,984	308,918	99,285
Germany .....	5,939	28,316	101,432	121,963	135,126
Rest of Europe.....	17,209	92,565	109,026	111,253	203,353
British Colonies....	14,899	16,334	29,916	60,229	52,149
South America.....	11,568	11,444	10,395	16,851	24,428
Rest of World.....	4,949	9,529	26,208	64,062	44,450
Total .....	\$221,089	\$261,914	\$555,718	\$770,929	\$782,090

Other Products.

OTHER PRODUCTS.

	1904.	1905.	1906.	1907.	1908.
Great Britain.....	\$1,016,000	\$1,045,000	\$1,095,000	\$1,125,000	\$1,214,000
Br. North America...	244,000	271,000	633,000	630,000	751,000
Germany .....	733,000	1,017,000	1,209,000	1,409,000	1,026,000
Rest of Europe.....	1,824,000	1,557,000	2,618,000	2,666,000	2,193,000
British Colonies....	39,000	51,000	45,000	16,000	33,000
South America.....	60,000	73,000	111,000	100,000	142,000
Rest of World.....	183,000	374,000	310,000	233,000	352,000
Total .....	\$4,198,764	\$3,349,561	\$6,070,186	\$4,171,626	\$6,750,698

## On the Equilibrium of the System Consisting of Lime, Carbon, Calcium Carbide, and Carbon Monoxide.

By M. DEKAY THOMPSON.

(Concluded from page 279.)

### EXPERIMENT I.

The charge consisted of lime, carbon and calcium carbide mixed together. A loosely fitting lid with a  $\frac{1}{4}$ -in. hole in the center covered the crucible. The mixture was placed in the furnace, the furnace was evacuated and the charge heated to 1000° for an hour to drive off gases that invariably come off on the first heating, and particularly to get rid of any water contained as hydrate of calcium. If this were not done water would come off during the run and react with the carbide present. The furnace was then evacuated to a pressure of 0.05 cm of mercury and carbon monoxide let in to 1.25 cm. This was generated from strong sulphuric acid and potassium ferrocyanide and was washed with two drying towers of soda lime and a phosphorous pentoxide tube. Hydrogen was then admitted to a final pressure of 63.6 cm. This was generated from hydrochloric acid and zinc and was purified by two bottles of permanganate, a hot copper gauze, two towers of soda lime and a phosphorous pentoxide tube. The furnace was filled with hydrogen in three-quarters of an hour. The volume of the furnace, after allowing for the solids present during a run, was 19.9 liters. The run began at 9.45 a. m. and lasted till 4 p. m. The power was held constant at 12.0 kw corresponding to 1485° C. The following table gives the analysis for carbon monoxide, made by drawing off 100 cu. cm into a Hempel burette and absorbing with acid cuprous chloride solution.

Time	Per cent carbon monoxide
9:45 a. m. Sample taken as furnace warmed up.	1.05

1:42 p. m. Less than 0.1.

It was evident from this result that the quantity of gas corresponding to equilibrium at this temperature could not be analyzed by a Hempel apparatus. The experiment was continued till 4 p. m. to make sure equilibrium had been reached. The method used to determine the small quantity of carbon monoxide present in this and all the following experiments was to draw about half the gas in the furnace through two Liebig bulbs sealed together and filled with cuprous chloride solution. These were tilted at an angle so the gas bubbled through the liquid on leaving each of the five spheres of which a Liebig bulb is composed. The gas then passed a column 7 cm long of



soda lime and another similar one of phosphorous pentoxide. This whole apparatus was made entirely of glass closed by two glass stopcocks. The bulbs, in which the air was displaced by hydrogen, were hung in the balance case by a platinum wire the day before the final weight was taken. The air in the balance case was dried by two beakers of sulphuric acid and the temperature was read from a thermometer in the case. The volume of the bulbs was determined by the bottle method for specific gravity, in which a large desiccator took the place of the bottle. This was necessary in order to be able to reduce the weighings to vacuo. From the total weight in grams of carbon monoxide absorbed the number of moles is formed by dividing by 28, the molecular weight of the gas. This, however, gives only a fraction of the total amount in the furnace. The total amount is calculated as follows: If  $n_1$  = the total number of moles in the furnace before any gas is removed,  $n_2$  the number after a certain amount had been drawn off through the absorption bulbs,  $p_1$  = the pressure in the furnace when the absorption began and  $p_2$  the pressure at the end, then

$$p_1 v = n_1 R T_1$$

$$p_2 v = n_2 R T_2$$

where  $v$  equals the volume of the furnace. The temperatures were equal to those of the water surrounding the furnace and were made equal to each other at the start and finish.

Therefore

$$n_1/n_2 = p_1/p_2$$

also

$$n_1 - n_2 = m$$

if  $m$  = the number of moles absorbed.

$$\text{Solving } n_1 = \frac{m}{1 - p_2/p_1}$$

If  $p_2$  = the total pressure during the run, which is greater than  $p_1$  on account of the higher temperature, the pressure in millimeters of carbon monoxide is computed by the formula

$$p = \frac{m \times 0.0821 \times T \times 760 \times p_1}{19.9 \times p_2}$$

in which  $T$  is the absolute temperature of the gas in the furnace at the beginning and at the end of the absorption.

At the end of the absorption the pressure of hydrogen in the absorption bulbs was only about half an atmosphere, consequently enough hydrogen had to be let in to bring the pressure to one atmosphere, after which the bulbs were again hung in the balance case and weighed the following day. The variation due to temperature and pressure change in the weight of hydrogen filling the bulbs was negligible. All weighings given in the following are reduced to vacuo. The data thus obtained after the above run were the following:

Initial weight bulbs.....	175.3392 grams
Final " " .....	175.3482 "

Gain in weight..... 0.0090 grams

The time taken for absorbing the gas was six hours.

$$p_1 = 68.5 \text{ cm of mercury}$$

$$p_2 = 38.6 \text{ " " "}$$

$$p_3 = 89.0 \text{ " " "}$$

$$\text{whence } p_{CO} = \frac{0.00074 \times 0.0821 \times 285 \times 760 \times 89}{19.9 \times 68.5}$$

$$= 0.86 \text{ mm of mercury.}$$

On opening the furnace, white powder was found on the lid.

#### EXPERIMENT 2.

The same charge as used in experiment 1 was ground up and replaced in the crucible. Part was tested with water and gave off acetylene vigorously. It was heated for an hour to 1000° and evacuated to a pressure of 0.05 cm of mercury. No carbon monoxide was admitted. Hydrogen was let in to 67.2 cm in 1 hour 40 minutes.

Duration of run, 6 hours.

Power, 11.7 kw.

Temperature, 1465° C.

Initial weight bulbs.....	182.5989 grams
Final " " .....	182.6061 "

Gain ..... 0.0072 grams

Time taken for absorption, 4½ hours.

$$p_1 = 67.2 \text{ cm of mercury}$$

$$p_2 = 38.1 \text{ " " "}$$

$$p_3 = 91.8 \text{ " " "}$$

$$\therefore p_{CO} = \frac{0.000589 \times 0.0821 \times 288 \times 760 \times 91.8}{19.9 \times 67.2} = 0.73 \text{ mm,}$$

On opening the furnace somewhat more white powder found on the walls than in experiment 1.

This experiment was carried out with the idea of approaching the equilibrium from the side which generates carbon monoxide. To decide whether this had been done in the above experiment it was necessary to see whether the bulbs would gain no weight if the furnace were filled with hydrogen and part then drawn through the bulbs. The following blank experiment was therefore carried out: The furnace was evacuated to a pressure of 0.15 cm of mercury, hydrogen was let in to 1 cm and again evacuated to 0.15. This operation was repeated and hydrogen then let in to 67.6 cm. The final filling took 1 hour 40 minutes.

The gas was then drawn through the weighted bulbs for 3 hours 45 minutes.

$$p_1 = 67.1 \text{ cm of mercury}$$

$$p_2 = 38.1 \text{ " " "}$$

Initial weight reduced.....	182.606 grams
Final " " .....	182.627 "

0.021 grams

If the whole amount of gas could have been drawn through the gain in weight would have been 0.049 gram. This gain in weight must have been due to oxygen, which might not have been removed or which might have gotten in while filling the furnace. This would have been converted to carbon monoxide by the hot carbon spiral giving too high a pressure for equilibrium. Equilibrium in experiment 2 was therefore approached from the same side as in experiment 1. This remark holds good for all the following experiments.

#### EXPERIMENT 3.

As the previous experiments agreed fairly well, it was thought desirable to try a lower temperature, to make sure that the gain in weight of the absorption bulbs was really due to carbon monoxide and not to some impurity in the hydrogen.

The charge consisted of fresh carbide, lime and carbon. The furnace was evacuated to 0.15 cm and was heated to 1000° till the occluded gases coming off gave a pressure of 6 cm, which required about 10 minutes. It was then evacuated to 0.15 cm with the furnace still at 1000°. Hydrogen was let in to 2.4 cm and evacuated 0.15. The furnace was then cooled and filled with hydrogen to a pressure of 67.0 in 1 hour 40 minutes.

Power, 8.24 kw.

Temperature, 1250°.

Duration of run, 6 hours.

The solution of cuprous chloride had been used in a previous experiment.

Initial weight of absorption bulbs....	183.6340 grams
Final " " " " .....	183.6372 "

Gain ..... 0.0032 grams

$$p_1 = 67.2 \text{ cm of mercury}$$

$$p_2 = 34.8 \text{ " " "}$$

$$p_3 = 90.4 \text{ " " "}$$

$$\therefore p_{CO} = \frac{0.000248 \times 0.0821 \times 286 \times 760 \times 90.4}{19.9 \times 67.2} = 0.30 \text{ mm.}$$

#### EXPERIMENT 4.

The charge was the same material as in the previous experiment with some lime and carbon added and mixed up with the rest.

The furnace was evacuated to a pressure of 0.2 cm and heated to 900° for two hours. It was then evacuated to 0.15 cm, hydrogen was admitted to 2.4 and again evacuated to 0.15. It was finally filled with hydrogen to 67.3 cm in 1 hour 40 minutes.

Power, 8.8 kw.

Temperature, 1270°.

Duration of run, 7 hours 10 minutes.

The absorption bulbs were refilled.

Initial weight.....	182.9303 grams
Final " .....	182.9316 "

Gain .....	0.0013 grams
------------	--------------

$p_1 = 66.8$  cm of mercury

$p_2 = 37.2$  " " "

$p_3 = 90.3$  " " "

$$\therefore p_{CO} = \frac{0.000103 \times 0.0821 \times 285 \times 760 \times 90.3}{19.9 \times 66.8} = 0.13 \text{ mm.}$$

#### EXPERIMENT 5.

The object of the following experiment was to see if measurements might not be carried out at a somewhat higher temperature where the pressure would be greater and the determination, therefore, more accurate.

The charge was the same carbide used in experiment 4 to which about one-half as much lime and carbon, previously heated to redness, was added. The furnace was then evacuated to 0.2 cm and heated to 900° for 1¼ hours. It was then evacuated to 0.2 cm and hydrogen let in to 2.3; again evacuated to 0.12 cm and filled with hydrogen to 67.7.

The charge was then heated seven hours with 100 kw corresponding to 1370°. This must have established equilibrium at this temperature. The power then was raised to 12.6 kw corresponding to 1525° for 4½ hours.

The cuprous chloride was the same used in experiment 4.

Initial weight.....	182.9243 grams
Final " .....	182.9277 "

Gain .....	0.0034 grams
------------	--------------

Time taken for absorption, three hours.

$p_1 = 66.3$  cm of mercury

$p_2 = 37.7$  " " "

$p_3 = 90.0$  " " "

$$\therefore p_{CO} = \frac{0.000280 \times 0.0821 \times 285 \times 760 \times 90.0}{19.9 \times 66.3} = 0.34 \text{ mm.}$$

On opening the furnace a larger amount of powder than any other experiments here given was found on the walls. This, taken in connection with the small pressure found and the experiments referred to in the introduction seem to indicate that at this temperature the carbon monoxide was removed by calcium coming from the decomposition of carbide.

It is true that this equilibrium was really approached from the side of too little carbon monoxide, but as the velocity of the reaction is the same in both directions at equilibrium, this cannot account for the low pressure of carbon monoxide.

#### EXPERIMENT 6.

The hydrogen used in the following experiments was generated electrolytically on platinum electrodes dipping into sulphuric acid of 1.2 specific gravity. The cathodes were contained in a porous cup closed at the top by a cork stopper covered with paraffine, through which projected glass tubes, into which the electrodes were sealed. There was also a tube through which hydrogen could escape. The porous cup stood in a small battery jar. The hydrogen tube was connected to a mercury manometer so that the pressure in the cathode compartment could be kept from 0.1 cm to 1.0 cm above the atmosphere, thereby preventing air from leaking in. In experiment 6 only one such electrolytic cell was used, but for the last two experiments another cell was connected in series with the first, thus requiring only half the time for filling the furnace. The hydrogen first passed through a soda lime tube, then the hot copper gauze used in the previous experiments, then two soda

lime towers and phosphorous pentoxide tube. Hydrogen was passed over the hot copper for at least half an hour before any was let into the furnace, in order to sweep out the air in the tube. The object in using electrolytic hydrogen was to show that the above gains in weight were not due to impurities in the hydrogen generated from zinc and hydrochloric acid.

The carbon monoxide used in the following experiments was generated by allowing formic acid to drop from a separatory funnel into concentrated sulphuric acid.

In order to see if all the carbon monoxide was absorbed by the two Liebig bulbs containing cuprous chloride, in the following experiments a second absorbing apparatus similar to the above was used with one Liebig bulb in place of two. This was filled with a 3 per cent solution of neutral gold chloride. This has been found to oxidize carbon monoxide to dioxide without affecting hydrogen.<sup>10</sup> Gold chloride in an excess of potassium hydrate is even more sensitive to carbon monoxide, but it was found that hydrogen reduced the gold in the alkaline solution to a black powder if left in contact with the solution over night.

The charge consisted of about equal portions of powdered carbide and a mixture of lime and carbon. It had been used in a previous run.

The cuprous chloride in the Liebig bulbs had been used in three previous experiments, but as a little was tested with water and gave a heavy white precipitate it was not thought necessary to change the solution.

The furnace was evacuated to a pressure of 0.28 cm and hydrogen was let in to 1.0 cm; then evacuated to 0.1 and carbon monoxide let in to 0.3 cm. Hydrogen was then admitted to 67.3 cm requiring three hours with a current of about 14 amp.

Duration of run, 6¼ hours.

Power, 11.8 kw.

Temperature, 1475°.

Initial weight cuprous chloride bulbs..	173.1312 grams
Final " " " " ..	173.1383 "

Gain .....	0.0073 grams
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Initial weight gold chloride bulb....	116.8119 grams
Final " " " " ....	116.8158 "

Gain .....	0.0036 grams
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Total gain .....	0.0110 "
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The gain in the gold chloride bulbs was relatively large, probably on account of the cuprous chloride having gotten so much carbon monoxide in solution that it was not so good an absorber as when fresh.

$p_1 = 65.7$  cm of mercury

$p_2 = 34.5$  " " "

$p_3 = 92.0$  " " "

$$\therefore p_{CO} = \frac{0.000703 \times 0.0821 \times 287 \times 760 \times 92}{19.9 \times 65.7} = 0.88 \text{ mm.}$$

#### EXPERIMENT 7.

The charge consisted of powdered carbide with some coarser pieces on top. It was heated in the furnace at 1050° for an hour and a quarter and evacuated to 0.1 cm. Hydrogen was then let in to a pressure of 1.6 cm, the furnace was evacuated to 0.10 and carbon monoxide let in to 0.25 cm. Finally, hydrogen was let in to 68.3 cm, requiring 1½ hours with 14 amp.

Duration of run, six hours.

Power, 11.8 kw.

Temperature, 1475°.

The cuprous chloride bulbs were refilled, but not the gold chloride.

Initial weight cuprous chloride bulbs..	173.7646 grams
Final " " " " ..	173.7695 "

Gain .....	0.0049 grams
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<sup>10</sup> Phillips, *Journ. Am. Chem. Soc.* 16, 273 (1894).



Initial weight gold chloride bulb.... 116.8121 grams  
Final " " " " .... 116.8126 "

Gain ..... 0.0005 grams

Total gain ..... 0.0054 "

Time required for absorption, three hours.

$$\therefore p_{CO} = \frac{0.00065 \times 0.0821 \times 291 \times 760 \times 95}{19.9 \times 69.3} = 0.81 \text{ mm.}$$

#### EXPERIMENT 8.

The charge was the same material as used in experiment 7. The furnace was evacuated and heated for 1 hour 50 minutes at 1050°. It was then evacuated to a pressure of 0.12 cm and hydrogen let in to 2.0, again evacuated to 0.15 and carbon monoxide let in to 0.28 cm. Hydrogen was then admitted to 77.6 cm, requiring 1¼ hours.

Duration of run, 6 hours 10 minutes.

Power, 11.4 kw.

Temperature, 1445° C.

The cuprous chloride bulbs were refilled.

Initial weight cuprous chloride bulbs.. 167.4274 grams

Final " " " " .. 167.4312 "

0.0038 grams

The tube previously used for gold chloride was filled with cuprous chloride.

Initial weight 2d cuprous chloride tube.. 119.3358 grams

Final " " " " .. 119.3363 "

Gain ..... 0.0005 grams

Total gain ..... 0.0043 "

$p_1 = 67.1$  cm of mercury

$p_2 = 37.7$  " " "

$p_3 = 92.7$  " " "

The time taken for absorption was 3¼ hours.

$$\therefore p_{CO} = \frac{0.000350 \times 0.0821 \times 287 \times 760 \times 92.7}{19.9 \times 67.1} = 0.44 \text{ mm.}$$

#### 3. DISCUSSION OF RESULTS.

For convenience the results obtained above are collected in the following table:

TABLE 4.

No. of Exp.	Duration in hours.	Kilowatts.	Temp. Centigrade.	Gain in weight of 1st bulb.	Gain in weight of 2d bulb.	Time taken for absorption, in hours.	Initial pressure CO in mm Hg.	Final pressure CO in mm Hg.
1	6½	12.0	1485	0.0090		6	12.5	0.86
2	6	11.7	1465	0.0072		4½	0.0	0.73
3	6	8.2	1250	0.0032		3½	0.0	0.30
4	7	8.8	1270	0.0013		2½	0.0	0.13
5	4½	12.6	1525	0.0034		3	0.0	0.34
6	6¼	11.8	1475	0.0073	0.0036	4	2.0	0.88
7	6	11.8	1475	0.0049	0.0005	3	1.5	0.81
8	6	11.4	1445	0.0038	0.0005	3¼	1.3	0.44

In all of these experiments, even at 1250°, there was some white powder on the walls of the furnace. Whether a slight decomposition of carbide into its elements takes place at this temperature could not be decided by this means, as the white powder may have been due to two causes, both the decomposition of carbide and the volatilization of some impurity in the lime or carbon. The best evidence that the carbide does not break up at 1475° and does break up at 1525° is that equilibrium could be measured at the former but not at the latter temperature. Attention was called to the possibility of lime itself being somewhat volatile at 1500°, since a piece of Merck's lime heated at the melting point of platinum for an hour also produced a layer of white powder on the walls of the furnace.

As experiments 1 and 2 were carried out at temperatures equally above and below the temperature in experiments 6 and 7, the average of these four may be taken, with the result

$$p_{CO} \text{ at } 1475^\circ \text{ C.} = 0.82 \pm 0.02 \text{ mm.}$$

Though these results were obtained from the same side of the equilibrium, different amounts of carbon monoxide were present at the beginning in each case, which makes the evidence that equilibrium had been reached conclusive.

From this result, the pressure obtained in experiment 8 at a temperature 30° lower may be checked by the integrated van't Hoff equation:

$$4.57 \log_{10} (p_2/p_1) = Q \left( \frac{1}{T_1} - \frac{1}{T_2} \right)$$

where  $p_2$  and  $p_1$  are the pressures of carbon monoxide corresponding to the absolute temperatures  $T_1$  and  $T_2$  and  $Q$  is the heat absorbed by the reaction, when it proceeds from left to right.  $Q$  has been calculated<sup>14</sup> to be 121,000 calories at room temperature, with a negative temperature coefficient of 3.3 calories per degree. Therefore

$$Q = 121,000 - 3.3t$$

where  $t$  equals Centigrade degrees above room temperature, which for high temperatures may be considered as degrees

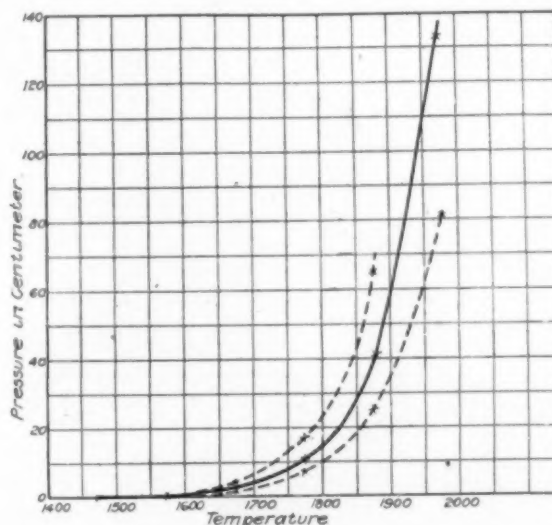


FIG. 3.—PRESSURE OF CARBON MONOXIDE COMPUTED FROM THE VALUE OBTAINED AT 1475°.

above zero. For 1460° C.,  $Q$ , therefore, equals 116,000 calories. Substituting in the above equation the absolute temperatures corresponding to 1475° and 1445°, the value of  $p_2/p_1$  comes out 1.79. The ratio between the pressures found by experiment is 1.86, which is very satisfactory agreement.

If the pressure at 1270° is calculated from that at 1475°, using the value of  $Q$  corresponding to the mean temperature

TABLE 4.

Pressures of Carbon Monoxide Computed from the Value Determined at 1475°.

Temperature Degrees Centigrade.	Equilibrium Pressure of Carbon Monoxide in Centimeters.		
	I. Lower Limit.	II. Mean.	III. Upper Limit.
1475	0.05	0.08	0.13
1575	0.31	0.50	0.79
1675	1.54	2.53	4.00
1775	6.6	10.7	17.00
1875	25.0	40.5	64.00
1975	81.0	133.0	210.00

1370°, the result is 0.0093 mm, that is, it is below a measurable quantity. The fact that in one case 0.13 and in another 0.3 mm

<sup>14</sup> Trans. Am. Electrochem. Soc., Vol. 15, 197 (1909).

were found is due to the insufficient time allowed to absorb this very small amount of carbon monoxide.

From the value of the equilibrium pressure obtained at 1475°, it is possible by the above formula to calculate the pressure at higher temperatures and see approximately what is the shape of the pressure temperature curve. The value of  $Q$  corresponding to the mean of each set of temperatures is used; 1475° is always taken as the lower temperature. The results of this computation are given in table 4 and plot 3.

It is evident that the error in this curve is due practically entirely to the error in the temperature measurements, for while the value of  $p_1$  is accurate to 2.5 per cent, the temperature is uncertain by 25°, and the value 0.82 mm might correspond to 1500° or 1450° as the two extremes. This would mean the true value at 1475° might be 1.3 mm or 0.5 mm as the two extremes. If now the curve be computed first with the value 1.3 in place of 0.82, and again with 0.5, the values under I and III in table 4 are obtained. These values are plotted in plot 3 in broken curves. From these curves it is seen the temperature corresponding to one-third of an atmosphere lies between 1800° and 1875°, with which Rudolphi's value agrees the best of the three referred to in the introduction.

The free energy increase of the reaction taken from left to right at 1475° C. is

$$F = RT \log \frac{760}{0.82} \\ = + 23,700 \text{ calories.}$$

As the temperature rises  $\Delta F$  decreases till at 1920°, where the equilibrium pressure equals an atmosphere,  $\Delta F = 0$ . Above 1920°  $\Delta F$  becomes negative.

#### SUMMARY OF RESULTS.

1. The equilibrium pressure of carbon monoxide in the reaction



was measured at 1475° and 1445°. The results were in good thermo-dynamic agreement.

2. A little below 1445° C. the pressure becomes too small to measure; a little above 1475° decomposition of calcium carbide into its elements prevents measurement of equilibrium.

3. With the aid of the heat of the reaction the vapor pressure curve at higher temperatures was computed which cannot be realized experimentally on account of the decomposition of calcium carbide.

4. The free energy increase of the reaction



at 1475° is + 23,700 calories.

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#### Tests of Bakelite.

As will be remembered from Dr. L. H. Baekeland's papers (our Vol. VII, pages 111 and 276), bakelite is a new synthetic product resulting from the chemical condensations of phenols and formaldehyde. Since the first announcement of its remarkable properties and wide usefulness, bakelite has undergone continually many tests, not only in the inventor's own laboratory, but in practical use by others for a great many different purposes. Naturally much of interest has been detected. For the information contained in the following notes, which will be found to contain much that is new, we are obliged to Dr. Baekeland.

Bakelite in its final stage (C) is hard, infusible, and insoluble; it then resists all solvents and almost all chemicals; it stands temperatures as high as 300° C. or over; at the temperature of melting glass it is destroyed and chars, without entering into fusion; it is charred by boiling concentrated sulphuric acid and by nitric acid; it is also attacked by bromine, which seems very remarkable, as it stands very well chlorine

and hydrochloric acid and cold sulphuric acid; boiling dilute sulphuric acid has no effect on it. Certain varieties can be made to stand hot caustic solutions.

Mixed with mineral substances like asbestos, its resistance to heat is considerably increased. In unmixed condition, it may appear as a perfectly transparent amber-colored substance, which is much stronger and more resistant than amber and can be turned and polished to a high finish.

Except for jewelry purposes, bakelite is most used compounded with other materials, for instance, asbestos, wood-fiber, mica, etc. On account of the great impregnating power of the initial raw products even quantities as small as 10 per cent of this binder are sufficient to produce very strong, compact, molded masses.

The specific electric resistance, dielectric strength, mechanical strength, maximum working temperature, etc., of bakelite vary considerably according to the nature of the compound. For instance, compounds with asbestos will stand considerably higher temperatures than those made with wood fiber. The latter are more adapted to turning, sawing and all purposes where great toughness is required. Bakelite compounds containing asbestos withstand very well high-pressure steam, even if the latter be at a temperature of 200° C. Pure bakelite electrifies by friction, which denotes high dielectric properties.

Asbestos-bakelite insulators do not show such high dielectric constants, but are very well adapted for voltages not exceeding, say, 40,000 volts. They have the considerable advantage over shellac or rubber insulators that they do not soften by heat and are considerably stronger.

Bakelite compounded with wood pulp shows higher dielectric strength on account of the fact that wood pulp does not contain disturbing materials, like iron, which is always present in asbestos. On the other hand, such wood-fiber bakelite insulators cannot well be used where the insulators are submitted for long periods to temperatures above 150° C., but they resist water and steam, oil and solvents.

As an example as to the general behavior of bakelite compounds, the following indications may be given:

A stick of pure bakelite was boiled continuously for 260 hours in 10 per cent sulphuric acid solid without alteration. A similar stick was submitted for two months, day and night, to a 10 per cent caustic soda solution at 70-80° C. without appreciable effect.

A steel pipe was lined with a thin coating of bakelite and kept for 21 days and 21 nights in hot damp chlorine gas at 60° C., without alteration.

Bakelite was kept in a steam digester for 12 hours at 200° C. (226 lb. steam pressure) without appreciable effect.

The results of a series of electrical and mechanical tests of bakelite and wood pulp and of bakelite and asbestos are given in the following table:

PROPERTIES OF BAKELITE INSULATING MATERIAL.

	Bakelite and wood pulp.	Bakelite and asbestos.
1. Specific resistance in megohms per cubic centimeter .....	35 x 10 <sup>8</sup>	0.01 x 10 <sup>8</sup>
2. Dielectric strength of thickness 0.375 inch in volts at moment of puncture .....	115,000	42,500
3. Dielectric constant in kilovolts per centimeter .....	121	45
4. Mechanical strength in pounds per square inch tension .....	650	1,200
5. Mechanical strength in pounds per square inch compression .....	4,000	18,000
6. Maximum working temperature in degrees centigrade .....	90	450

The electrical value of bakelite depends entirely on the composition and the way in which it is molded and cured. Values as high as 66,000 volts puncture on a thickness of 0.02 in. have been obtained by special treatment of this material.

Bakelite compositions can be made very strong mechanically, and will resist the impact of suddenly applied loads.

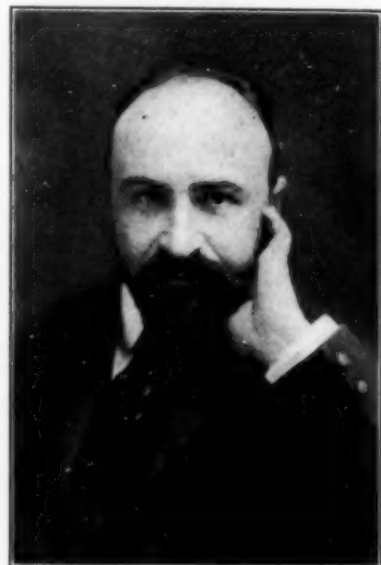
The material weathers perfectly without any signs of hydrolysis, and surfaces so exposed show a peculiar tendency toward preventing surface creeping or leakage.



## Pittsburgh Meeting of the American Electrochemical Society

The seventeenth general meeting (and the ninth annual meeting) of the American Electrochemical Society was held in Pittsburgh from May 4 to 7 and turned out an immense success. It was the best attended meeting so far held by this society; the attendance reached almost the 500 mark, there being some 460 names in the last printed registry list.

The meeting was exceedingly well organized and the highest credit is due to the members of the Pittsburgh local committees for the carefulness and completeness with which all arrangements had been made.



L. H. BAEKELAND, RETIRING PRESIDENT  
AMERICAN ELECTROCHEMICAL  
SOCIETY.

Mr. Charles F. Scott, of the Westinghouse Electric & Manufacturing Company, was the chairman of the executive committee, and a wonderfully successful and unfailingly courteous chairman he was. Messrs. F. Crabtree, H. K. Hitchcock, P. Kemery, H. H. Laughlin, R. S. Orr, Hugh Rodman, and S. S. Wales were the other members of the executive committee and the chairman of the various subcommittees. But it was really whole industrial Pittsburgh that heartily welcomed and royally entertained the society.

An account of the social functions and of the various most en-

joyable and instructive excursions is given at the end of this report.

### Thursday Morning Session.

The first professional session was called to order by the president, Dr. LEO H. BAEKELAND, on Thursday, May 5, at 10 a. m., in the lecture hall of the Fort Pitt Hotel.

Mr. B. F. MORSE, president of the Engineers' Society of Western Pennsylvania, welcomed the society to Pittsburgh in a very felicitous little speech, full of interesting personal reminiscences concerning the development of industrial Pittsburgh since the Pennsylvania Railroad came to the city in 1852.

He said that what will be remembered as the greatest achievement of the Roosevelt administration is the inauguration of a systematic organization of the policy of conservation of our natural resources. In days to come the big stick will be forgotten, but the policy of conservation will remain. In this field much is to be expected from the work of electrochemists, also in connection directly with Pittsburgh. There is a tendency of the center of industrial activity to move gradually away from Pittsburgh to the West. Much can be done by electrochemists to keep the center of gravity fixed at Pittsburgh.

To show how it can be done, Mr. Morse gave an account of the work of the Pittsburgh "flood commission." Forty or 50 public-spirited engineers are giving their services free to the work of surveying the headwaters of the rivers around Pittsburgh for the purpose of locating the rainsheds that cause the rivers to overflow their banks at certain seasons. In one flood there was a direct loss of \$4,000,000 in two days. The object of the flood commission is to prevent such damage, to harness the

waters and get electricity out of them, and employ it usefully in the Pittsburgh mills. In this development electrochemists can and must help.

Mr. CHARLES F. SCOTT, as chairman of the local executive committee, followed with a speech of welcome to industrial Pittsburgh. The doors of all the magnificent industrial establishments would be wide open to the society. In the great history of Pittsburgh output and quantity has been the keyword of the past, quality and economy will be the keyword of the future.

The annual report of the board of directors was then presented by the secretary of the society, Dr. Joseph W. Richards. The society is in a flourishing condition financially and the membership is rapidly increasing. Two hundred and ninety new members were elected in 1909, the total number of members at the end of 1909 was 1066; it is now above 1200. The formation of a Chicago local section has been authorized by the board of directors.

The results of the election of officers were then announced. Dr. William H. Walker, of the Institute of Technology of Boston, is the new president of the society. Mr. Pedro G. Salom and Dr. Joseph W. Richards were re-elected treasurer and secretary, respectively. Dr. E. F. Roeber, Mr. S. S. Sadtler, and Dr. Louis Kahlenberg were elected vice-presidents for two years; Prof. Charles F. Burgess, Mr. C. P. Townsend, and Dr. W. R. Whitney managers for three years.

### Laws of Furnace Electrodes.

Two papers were presented by Mr. CARL HERING, of Philadelphia, Pa., on the laws of furnace electrodes. The first paper was entitled "Determinations of the Constants of Materials for Furnace Electrodes"

made of carbon, graphite, iron, and copper. The method of determination is that described in Mr. Hering's former Am. Electrochem. Soc'y paper (our Vol. VII, page 514). The results of these determinations were already given in Mr. Hering's recent Am. Inst. Elec. Eng. paper, abstracted in our May issue, page 238. His present paper describes the details of these tests.

Briefly described, the method consists in imbedding a rod of the material to be tested in a heat-insulating material, allowing the two ends to project sufficiently for terminals. A steady current is then passed through it which will heat it; it becomes hottest midway between the ends. The temperatures at the middle and at the ends, the voltage at the two ends, and the current are then measured. From this data all the necessary physical constants are then calculated.

The mean resistance is the quotient of the volts and the amperes; from this and the size of the rod, the mean resistivity is



W. H. WALKER, PRESIDENT-ELECT, AMERICAN ELECTROCHEMICAL SOCIETY.

calculated. The product of the volts and amperes gives the heat flow in watts, which flows out at the two ends, and from this and the dimensions the heat conductivity is calculated.

The rod is equivalent to two electrodes butting together at their hot ends, the interior of the furnace itself being omitted; hence the entire flow of heat is that due to the resistance of the electrodes, which is the condition under which a well-proportioned electrode should operate. The rod is assumed to be perfectly heat-insulated; this is nearly accomplished by surrounding it with a cage of similar rods through each of which the same current passes.

A stable state of temperature is, of course, essential, and the calculated constants are the correct mean values under electrode conditions; these mean values represent those which an equivalent electrode would have whose conductivities are the same from end to end.

The electrodes were circular rods 18 in. long and about  $\frac{3}{8}$  in. diameter. Seven equal electrodes were used in series in each test; the rod under test being in the center, with the six others arranged as a cage around it. The refractory material used for imbedding the rods was very finely pulverized magnesite.

The couplings at the outside ends were water-cooled and were soldered to the ends of the rods; this took up 1 in. at each end, having 16 in. clear length of rods between terminals, thus forming two 8-in. electrodes butting together at their hot ends. The couplings connected all the rods in series. The two for the two ends of the middle rod had slots cut into them permitting a thermometer or thermo-couple and pointed wires for voltage measurements to be inserted to touch the electrode under test at the exact point of emergence from the furnace; hence the rod under test was exactly 16 in. long, and the heat which might be generated in the contacts with the terminals was eliminated.

A pyrometer was inserted with its end just over the middle point of the test electrode for measuring the high temperatures. The current was supplied by a motor driven, separately excited, direct-current dynamo of low voltage and high amperage.

Each test consisted in passing a current through the series of rods until the stable state of temperature had been reached, as shown by the pyrometer. The temperature in the center, those at the two ends, the drop of voltage between the two ends, and the current, were then measured. This was repeated for each of a number of different temperatures. And these tests were made for carbon, graphite, iron, and copper.

The paper contains considerable details of the arrangement of the tests and records various observations made in carrying them out. It is very important to wait with each measurement until the steady state of temperature is reached. This may require several hours, depending upon the conditions. To determine whether the steady state is reached, it is necessary to take repeated readings of the pyrometer to see whether it has ceased rising.

The high temperatures were measured with a platinum, platinum-rhodium thermo-couple made especially for this test with long wires, the electromotive forces being measured with a potentiometer, thereby avoiding the error due to a current. The use of a potentiometer with this thermo-couple also enabled widely different temperatures and small changes in them to be measured with very great accuracy.

The great importance of this accuracy was not to measure the temperatures so closely, but to determine the stable state—that is, to determine accurately whether all the interior parts had reached their maximum temperature.

Notes are given on special protection of the test tubes and on their deterioration at higher temperatures. If the gases in the granular refractory material are the cause of the deterioration, Mr. Hering suggests to carry out the test in a vacuum furnace.

The second paper of Mr. CARL HERING is entitled "Empirical Laws of Furnace Electrodes." Its object is to analyze his experimental results with a view of finding whether any of the

physical properties involved follow some approximate general laws. This refers especially to the "watts per amperes"  $E$  and the "section per ampere per inch length"  $S'$ . (See definitions on p. 238 of our May issue.)

The relation between the quantity  $E$  (watts per ampere) and the temperature drop  $T$  is given by a hyperbolic formula

$$E^2 = aT + bT^2,$$

where the constants  $a$  and  $b$  have the following values:

	$a$	$b$
Carbon .....	0.00373	0.00000366
Graphite .....	0.00256	-0.00000710
Iron .....	0.0000369	0.00000116
Copper .....	0.0000176	0.000000399

Since  $b$  is negative for graphite, the curve is an ellipse for graphite.

The relation between  $S'$  (square inches per ampere per inch length or square centimeters per ampere per centimeter length) and the temperature drop  $T$  is given by the formula

$$S' = m + n/T$$

where the constants  $m$  and  $n$  have the following values:

	Inches.		Centimeters.	
	$m$	$n$	$m$	$n$
Carbon ....	0.000200	0.483	0.000508	1.23
Graphite ...	0.000173	0.0665	0.000440	0.169
Iron .....	0.0000967	0.00262	0.000246	0.00666
Copper .....	0.0000129	0.000888	0.0000329	0.00226

The author also discusses the reciprocal of  $S'$  (the current for 1 in. length per square inch section) and the conductivities and gives some other deductions.

In the discussion which followed Mr. Hering's papers, some theoretical notes communicated by Dr. A. E. Kennelly, of Harvard University, were first presented. The principal result of his analysis is that Mr. Hering's empirical relations between the various properties of iron and copper may be accounted for, first, by the Wiedemann-Franz law, and secondly, by the approximate constancy of the thermal conductivity and thermal resistivity of these metals throughout the range of temperature drop covered by the observations.

Mr. H. W. Gillett, of Cornell University, thought it was not the normal case that the tip of the electrode was at the temperature of the furnace itself so as to prevent heat outflow through the electrode. This condition could certainly not be obtained in an arc furnace. He gave some experimentally determined temperature gradients in graphite and carbon electrodes, at each 15 minutes of the run of a carborundum furnace, and emphasized the great similarity in the temperature curves for graphite and carbon. "Hence it seems that Mr. Hering takes too pessimistic a view of the carbon electrode in commercial furnaces. The similarity of the curves for carbon and graphite is not due to graphitization of the tip," since the tip of the carbon electrode was not graphitized to any appreciable extent. "Finally, since in the carborundum furnace at least it is not at all difficult to measure temperatures between 1500° C. and 2500 C. to from 10° to 20°, not only concordantly, but accurately, and since this is the range in which most commercial furnaces operate, we feel that any electrode formulas should be really tested on carbon and graphite electrodes to temperatures beyond the 900° C. given as the highest point in Mr. Hering's table."

Mr. Hering replied that the furnace in Mr. Gillett's experiments was not operated under the conditions specified in Mr. Hering's analysis that the hot electrode end should be at exactly the same temperature as the furnace interior, so that no heat flows through this end in either direction. This, he emphasized, is the proper or correct way of operating a furnace or designing an electrode, and it is possible to make the arrangements in such a way as to fulfill this condition, but it was not fulfilled in Mr. Gillett's experiment, nor did he reach the stable temperature condition to which the theory applies. Mr.



Gillett replied that the closeness of the final temperature curves showed that the stable condition had almost been reached.

Mr. Liddbury asked whether Mr. Hering's values above 900° were all extrapolated. This was confirmed by Mr. Hering.

Dr. J. W. Richards expressed his appreciation of the value of the experimental data of Mr. Hering, but called attention to a great discrepancy between some heat conductivity values given by Mr. Hering and experimental determinations of others. Mr. Hering emphasized that his figures of mean conductivities were not based on any assumptions, but were derived directly from the experiments. Mr. Queneau stated that in experiments on the relative conductivity of refractory brick he had found values for carbon and graphite which confirmed Mr. Hering's figures.

#### Heavy Alternating-Current Conductors.

A paper by Mr. R. C. RANDALL, of the Westinghouse Electric Laboratories, was entitled "a study in heavy alternating-current conductors for electric furnaces." The author first emphasized the importance of considering the nature of the service for which the conductors are intended.

When currents of 10,000 amp and up to 40,000 amp or 50,000 amp are contemplated, conductors very heavy in section are immediately suggested. Viewed from considerations of resistance alone the problem is quite simple, but to alternating current, unlike direct current, the simple resistance of a conductor is not a measure of its suitability. Alternating current does not take full advantage of the conductivity of an ordinary conductor; it does not distribute itself uniformly throughout the section, but favors the area near the surface and shuns the central areas of the conductor section. A portion of the center of the section of a cylindrical conductor might be removed without appreciably impairing the effective conductivity for the alternating current.

**Skin Effect.**—The surface distribution of the alternating current is termed "skin effect," and is more pronounced for higher than for the lower frequencies; that is, as the frequency more nearly approaches direct-current conditions, namely, zero frequency, so does the importance of skin effect diminish. With small conductors of  $\frac{1}{2}$  in. or even 1 in. in diameter, the skin effect at 25 cycles is negligible, but with a 2-in. round conductor the skin effect has already reached such a value that the effective resistance has increased 25 per cent compared with direct-current conditions.

For 60 cycles, the  $\frac{1}{2}$ -in. conductor begins to experience a trifling increase in the effective resistance; the 1-in. conductor experiences an 11 per cent increase and the 2-in. conductor more than 80 per cent increase—that is, its effective resistance is nearly doubled. Furthermore, this is true independent of the current density which is employed. For example, a 2-in. copper rod (at 20° C.) 78 ft. long will carry 5000 amp direct current with an ohmic drop of 1 volt and an energy loss of 5000 watts. With 25-cycle alternating current and the same current, the ohmic drop would be 1.26 volts and energy loss 6300 watts; with 60-cycle current, 1.82 volts and 9100 watts loss.

These considerations would lead one to infer that for 60-cycle service it would be necessary to practically double the conductor section, and for 25 cycles to increase the section about 25 per cent in order to comply with direct conditions. This conclusion, however, is misleading, for if a 2-in. conductor had been increased 82 per cent in section, the effective resistance of the conductor to 60-cycle current would still be about 25 per cent greater than the original 2-in. conductor, to the passage of direct current. Fortunately, the conductance of heavy conductors can be improved even for fairly high frequency alternating currents without the excessive increase in section, as outlined above.

**Shape of Section and Form of Circuit.**—In addition to the sectional area of the individual conductor, the shape must be considered when alternating current is to be transmitted. For a given conductor area, as far as effective conductance is

concerned, the poorest solid section form is round, and the best is a very thin, flat sheet. If the sheet be rolled into a thin-walled tube, it represents less resistance than even the solid rod. Or the solid round conductor might be replaced by a laminated unit made up of a large number of separate small conductors, each of which has the same resistance and averages the same mechanical position throughout the length of the transmission. Each small unit would then be equally attractive to the alternating current, that is, each would carry a like current and the distribution throughout the combined conductor would be uniform and the "skin effect" would be eliminated. In practice, such an arrangement cannot be carried out conveniently, and approximations must suffice.

Besides the consideration of the individual conductor as to size and shape, it is necessary to go further and consider the form of the heavy current circuit—that is, the relative position of the coming and going conductors. Here the currents in the going and return conductors take the inner areas of closely adjacent conductors (as shown in end section by circles), thus not enjoying the full conductivity afforded by the conductor sections. The same remedy as for bad distribution applies, namely, laminating or breaking up into many individual conductors.

From the considerations so far, it is seen that in addition to considering the simple ohmic resistance which the direct current encounters in a circuit, it is necessary in alternating-current work to contemplate the shape and size of the individual conductor and also the form and dimensions of the heavy-current circuit.

In order to discuss some of the limitations encountered in practice, a furnace installation operating at 100 volts, 25 cycles, is assumed, the conductor arrangement and service being such that a power-factor of 90 per cent is obtained at rated full-load current. As the impressed voltage is 100 and the useful or working voltage is 90, the reactance voltage is 43. These 43 volts—the measure of the self-induction in the circuit—cause little concern under the assumed conditions.

But assume, further, that it becomes necessary to operate at 60 cycles. The reactance voltage is proportional to the frequency and current, so that on 60 cycles and the same current their value would become  $60/25 \times 43 = 103$  volts, or more than the total impressed voltage. This means that this furnace, even with the electrodes short-circuited, would not quite take full current from a 60-cycle circuit, and similarly on the original 25-cycle circuit something less than  $100 \div 43 = 2\frac{1}{2}$  times full-load current would be delivered under short-circuit conditions. If it were desired to increase the electrical input to the furnace, as by increasing the current through some adjustment of the electrodes, a maximum of approximately 130 per cent could be delivered. For with the fixed 100-volt supply an increase of current will increase the value of the reactance voltage and correspondingly decrease the working voltage.

The maximum input (on 25 cycles) occurs when the base and altitude are equal, namely, when each is 71 volts, a condition obtained by a current input of 165 per cent. The product of current (165 per cent) and voltage (71 per cent) is (118 per cent) proportional to the energy input and is approximately 30 per cent greater than (100 per cent  $\times$  90 per cent = 90 per cent) the rated load input to the furnace.

**Capacity Limitation by Frequency and Voltage.**—For a 60-cycle circuit the normal full-load current is much too large to give the maximum input. In general, the maximum energy that can be fed into a circuit at different frequencies will be inversely proportional to the frequencies, and will exist at a power-factor of 71 per cent. The assumed installation, though quite satisfactory for 25 cycles, would not be good for 60 cycles. A change in the arrangement of the conductor system so as to reduce the self-induction (reactance volts) would be necessary.

If, instead of 100 volts, but 60 volts had been used, a maximum input of 36 per cent would be obtained with 25-cycle cur-

rent as compared with the maximum input for the 100-volt service. At 60 cycles the maximum input would be but 42 per cent of 36 per cent, or approximately 15 per cent. Similarly an increase in the service voltage would increase the possible energy consumption. For example, 120 volts, 25-cycle supply would make the maximum input about 145 per cent and correspondingly 60 per cent for 60-cycle current. In general, energy input to a circuit for a given frequency is proportional to the square of the impressed voltage.

If there be an appreciable loss in the transmission circuit, the power-factor of 71 per cent for the whole system will not correspond to the maximum energy dissipation in the furnace, although it does give the condition for maximum energy in the whole circuit, including leads, terminals, electrodes, etc. The power-factor corresponding to maximum energy in the furnace is dependent on the resistance  $R$  and the reactance  $pL$  of the feeding system, and has a value between 0.71 and unity. It has a value of 0.71 when  $R = \text{zero}$  (the condition assumed in the installation discussed), and has the value unity when  $L = \text{zero}$ , a condition which can only be approached in ordinary practice.

As the function of an electric furnace is one of heating materials, and its capacity is in a measure determined by the amount of energy consumed in it, it may be said that the capacity of the furnace is determined by the maximum energy which can be dissipated within it, and this is determined by the operating power-factor, as pointed out.

The influence of power-factor on the capacity of the generating station is not discussed, but there is an evident relation of power-factor to this part of a system.

The weight of conductors for very heavy currents is quite considerable, and good mechanical provisions must be made for their support. Besides having mechanical strength, the supports must be insulators, although the potentials involved will usually be only about 100 volts. The necessity for laminating and interlacing the conductors in heavy-current work complicates the support problem. The contacts and connections between different parts of the circuit and the terminals of the apparatus, where the heavy current is to do its work, are also serious problems of this work.

A popular method of arranging conductors for moderate capacity installations employing 2000 amp to 5000 amp is the use of a number of stranded cables disposed alternately of opposite signs (from opposite sides of the circuit), as in this way an effective interlacing is accomplished which terminates at the service point where the cables of like sign are joined to the proper terminals.

Besides the questions of self-induction and effective resistance as influenced by shape and size of conductor and form of circuit, there exists the additional question of the use of different materials, notably copper and aluminium for conductors. These materials offer different resistances to the passage of direct current, and their factors for "skin effect" are not the same. For the same section the factor is somewhat greater for copper but practically the same for sections of equal resistance.

The efficiency of a heavy current conducting system is, in importance, on a par with the importance of the efficiency of the transformer and line from which the power will usually be obtained. Therefore, the question of loss in the heavy conductor system may be viewed in the same way as the loss in the other parts of the transmission and transformer system. And according to the importance of these considerations will the warrant for expenditure to reduce losses be determined.

In the preceding it is pointed out that conditions for maximum energy consumption in a circuit correspond to a power-factor of approximately 70 per cent, and although this is true, the conclusion should not be that a power-factor of 70 per cent is most desirable, because in general this is not the case; the higher the power-factor the more satisfactory the operation. But it is interesting to note that when a furnace or similar energy-consuming device must be forced to its maximum energy consumption from the constant-voltage circuit, this con-

dition does not correspond to high power-factor operation. The limitations under these special conditions are given in the following:

(1) The maximum power in a system containing reactance occurs when the total ohmic voltage ( $CR$ ) equals 71 per cent of the impressed voltage.

(2) The maximum power occurs in a furnace (resistance load) when the power-factor of the system has a value given by

$$0.71 \sqrt{1 + \frac{R}{\sqrt{p^2 L^2 + R^2}}}$$

where  $R$  and  $L$  are, respectively, the resistance and self-induction in the feeding circuit.

(3) Input to a circuit for a given frequency is proportional to the square of the impressed voltage.

(4) The maximum energy that can be fed into a constant-voltage circuit at different frequencies will be inversely proportional to the frequencies, and will exist at a power-factor of 71 per cent.

In general as a summary the following points may be noted:

The size and shape of conductors and operating frequency determine the magnitude of "skin effect."

The form and dimensions of the circuit and the frequency determine the self-induction.

"Skin effect" and self-induction are reduced by laminating the individual conductors, by the selection of conductors of the proper size and shape, and by interlacing the conductors.

The reduction of the self-induction in the circuit is the most important and most difficult.

In the discussion which followed, Mr. C. A. Hansen gave figures on the influence of the leads on the total resistance and reactance of a 10,000-amp furnace, and also gave a table which showed the maximum power input of the furnace at constant voltage taking place at a power-factor of 0.71.

Dr. M. G. Lloyd referred to the use of two concentric tubes as carriers of an alternating current, the inner tube being water cooled. There is no external magnetic field with such an arrangement.

#### Electric Steel Refining.

Mr. A. L. QUENEAU presented a preliminary paper on "A New Electric Steel Furnace." He briefly sketched the object of his furnace design, which was already noticed and illustrated in our March issue, page 149.

Mr. Queneau proposes to utilize the pinch effect to produce regular pulsations in an electric furnace charge in order to thoroughly mix it. One or more electrodes are in the bottom, and for a steel furnace these electrodes are rods of steel; their upper ends are in direct contact with the molten steel charge. These upper ends of the steel electrodes are molten and by providing a small restriction of the cross-section of the rod at that point the pinch effect is to be produced. The molten column of steel is thereby interrupted, but is immediately closed again by the weight of the charge above. In this way a series of regular pulsations is to be produced. The erection of this furnace has been somewhat delayed, and for this reason no results of experiments could be given in the paper. They are promised for a later meeting.

Replying to a question of Mr. Hansen as to the material of the refractory surrounding the molten steel where the continual make-and-break is to be established, Mr. Queneau said that he proposed to use magnesite laid in tar. Mr. Hansen questioned the possibility of keeping the refractory lining intact at that place under the severe conditions of operation.

#### Gases in Steel.

Dr. PAUL HÉROULT, of La Praz, France, presented a brief but suggestive paper on "gases in steel," maintaining that they are generally harmless and are present to about the same extent in all kinds of steel.

It is well known that when a thoroughly sound steel ingot



is placed in a vacuum chamber, a certain amount of hydrogen and nitrogen gases is exhaled and thrown off. The popular doctrine is that the percentage of the gases present is in proportion to the opportunities of absorbing them as a result of the process employed in producing the steel. But Dr. Héroult emphasizes that in the course of thorough and repeated investigations the quantities of gases so liberated have proven to be about the same, whether it be Bessemer steel or basic or acid open-hearth steel or crucible steel or electric steel. Dr. Héroult maintains that these gases are "absolutely innocent" and are not the cause of the production or presence of blow-holes.

On the other hand, blow-holes in steel ingots invariably contain hydrogen and nitrogen, often with only traces of carbon monoxide. Dr. Héroult, therefore, discusses the way in which blow-holes form. With the exception of accidental blow-holes due to a poor condition of the molds, blow-holes are the result of a disengagement of carbon monoxide. But this carbon monoxide does not pre-exist in the steel; it is only produced when the steel cools down and part of it has become solid. Steel that will produce blow-holes contains in the molten state carbon and at the same time iron protoxide. As long as the steel is molten and hot, these two bodies can keep apart, and for each temperature and each composition of steel there is a state of equilibrium at which no chemical reaction takes place. The heat is then what the Germans call "gar"—that is to say, dead melted.

"If the temperature is increased the reducing action of carbon will be intensified, and carbon monoxide will be evolved. If, on the contrary, the temperature is lowered, nothing happens till the steel gets partially solidified, with the effect that carbon and iron protoxide are crowded in a small space, in what we might call the mother liquor, and monoxide of carbon is evolved. The blow-holes produced are filled with carbon monoxide at a high temperature. As this gas cools down, however, it creates a vacuum and we then repeat the conditions of the ingot in the vacuum chamber."

That is, the vacuum now causes hydrogen and nitrogen to be given off from the steel, and this is the reason why blow-holes contain hydrogen and nitrogen.

In conclusion Dr. Héroult emphasized again that "steel does not contain any gases to amount to anything, and whatever small quantities it does contain are not injurious or detrimental to its quality. As a matter of fact, Bessemer steel, either acid or basic, which has every possible opportunity of absorbing gases, does not contain any more than any other steel."

In the brief discussion which followed, Dr. R. Amberg referred to the recent work of some French investigators on gases in steel. Boudouard (*Revue de Metallurgie*) and Belloc (*Bull. Soc. d'Enceur.*) both worked in a vacuum and found that the steel exhales gases only after a continued treatment for a certain time, which in all cases was longer than industrial processes would permit to apply. He also referred to some recent patents of Girod who proposes to produce steel free from gases by cooling a superoxidized bath or a bath still containing a certain amount of combustible elements down to low temperature by the addition of cold scrap, to 700° C. to 900° C. in one case or to 1100° C. in another, while it was stated that 400° C. to 500° C. would be still better if attainable. Dr. Amberg had tried this reaction both in superheated and in non-superheated steel in an electric furnace and could not observe any evolution of gases, below, say, 1200° C. In the first moment, of course, while throwing cold metal into a hot furnace at 1800° C. a development of gases takes place which is due, however, to quite another cause. Dr. Héroult replied that a method of removing gases at low temperatures would not be applicable in practice in his opinion. Dr. J. W. Richards pointed out that as a simple calculation shows, even a very small percentage of oxygen in steel (in form of iron oxide) when combining with carbon will give rise to a very large volume of gas; hence the attempts to eliminate any oxygen whatsoever from the steel.

### Electrolytic Preparation of Magnesium.

The preparation of magnesium by electrolysis of various fused electrolytes was the subject of a paper by Prof. SAMUEL A. TUCKER and Mr. FAREL L. JOUARD, of Columbia University.

According to text books, electrolysis of fused **magnesium chloride** gives the metal and chlorine. This method was first tried by the authors. The bath should consist of a mixture of magnesium and potassium chloride in molecular proportions. This combination is found in the mineral carnallite, but the mineral itself is unsuitable for the process. The effect

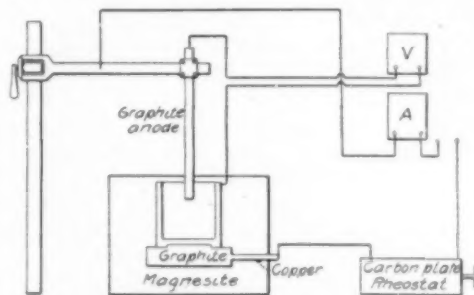


FIG. 1.—CARBON CRUCIBLE ELECTROLYSIS OF MAGNESIUM CHLORIDE.

of the potassium chloride is to prevent the decomposition of the magnesium chloride and also to lower the melting point of the bath. In fusing the two chlorides together it is found desirable to add ammonium chloride, as this also hinders the decomposition of the magnesium chloride. There are two varieties of magnesium chloride on the market—the crystals  $MgCl_2 \cdot 6H_2O$  and the so-called "fused." The latter appears to contain almost as much water as the former, and it is, therefore, better to start with the crystallized compound.

A mixture is therefore made of  $MgCl_2 \cdot 6H_2O$ , 203 parts;  $KCl$ , 74 parts;  $NH_4Cl$  sublimed, 50 parts.

As the magnesium chloride is deliquescent the resulting fusion will probably not contain the two chlorides in molecular proportions, but experience has shown that this makes little difference in the subsequent electrolysis.

At first graphite crucibles were used to fuse down the mixture, heating with a gas flame and also in some cases in a granular carbon electric furnace. If heated by a gas flame, care should be taken to keep the products of combustion from being absorbed by the fusion. This can be accomplished by the use of an asbestos shield with lateral openings for the escape of the

gases. One advantage of graphite crucibles for this operation is from the reduction of any sulphates present with elimination of the sulphur dioxide, but graphite seems to be porous to some extent to the fused chlorides and the yield of fused material is not very good.

In the subsequent work platinum was used, the same precautions being taken to keep out the products of combustion from the blast lamp. The mixture is added in small portions, allowing time for the steam to escape and also keeping the temperature of the mass low enough to prevent decomposition. When

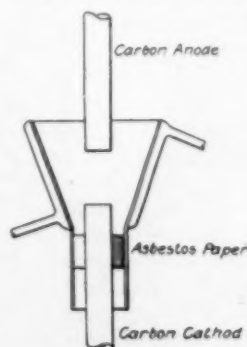


FIG. 2.—MUTHMANN CRUCIBLE.

the mass is uniformly melted the ammonium chloride will have been eliminated, and if the temperature is raised decomposition of the magnesium chloride will result and the melt will become cloudy. It should, therefore, be poured into a mold before this stage is reached and, after breaking up, bottled at once. During the fusion stirring with a carbon rod tends to break up the sulphates. The yield of fused material is about 50 per cent of the fusion mixture.

It is important that overheating of the mass of chlorides dur-

ing fusion be avoided, as experiment showed a loss of 37.7 per cent of magnesium by decomposition and 1.12 per cent by volatilization when the mixed chlorides were kept at low red heat for 30 minutes. These results were obtained by analysis of the starting mixture and the subsequent melt.

After some experiments on a very small scale (in which the addition of a small quantity of calcium fluoride proved beneficial by tending to unite the small globules of metal) the apparatus (Fig. 1) was derived.

The graphite crucible,  $2\frac{3}{4}$  in. diameter,  $3\frac{1}{2}$  in. high, is entirely surrounded by heat-retaining layers of magnesite and the passage of the current is sufficient to maintain the bath in fusion. The current used was 150 amp at 30 volts. The whole apparatus was placed in a hood to take off the chlorine which otherwise is unbearable. The apparatus can be started with a cold charge by drawing an arc with a small carbon rod, but it is easier to add the charge in the molten condition.

It was found best to make the vertical rod  $1\frac{1}{4}$  in. diameter, the anode and the crucible cathode, though the reverse will work fairly well. If the temperature is not raised too high, the metal collects at the bottom and side of the crucible in a spongy form which is easy to remove from time to time. The sponge is afterward united with an excess of calcium fluoride and some magnesium potassium chloride, so that it unites to a large globule.

The authors describe in detail six different runs which they made with this apparatus. From the results it would appear that the presence of calcium fluoride is beneficial, while the presence of magnesium oxide is to be avoided.

Further experiments were made in a crucible designed by Muthmann<sup>1</sup>. The apparatus consists of a small conical copper crucible having a tube or opening at the bottom through which one of the carbon electrodes enters. The sides of the crucible are provided with a copper water jacket which congeals the charge so that the copper is protected. The other electrode is a vertical electrode of carbon which can be adjusted vertically (Fig. 2.)

The mixed chlorides were added to the crucible cold, and were easily melted by a small arc between the electrodes, the upper electrode was made anode and the metal collected at the lower one in one globule and as it increased in size it would rise to the surface, interfering somewhat with the position of the anode. In a run of 28 minutes, with a mean current of 33.6 amp, 3.34 grams of metal were obtained, the theoretical yield being 7.12 grams.

The apparatus worked very well, using very small quantities of charge, and on cooling a slight tap at the lower electrode easily detaches the charge. As Muthmann has succeeded in using the crucible to advantage in other electrolytic work it is described how the crucible was made.

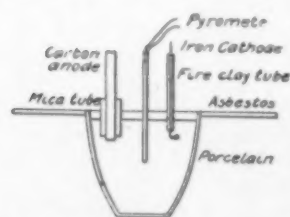


FIG. 3.—PORCELAIN CRUCIBLE.

A piece of copper tube,  $1\frac{1}{4}$  in. diameter,  $1/16$  in. wall, and 4 in. long, is spun to a cone at one end, beginning with the lathe and finishing on the anvil with hammer; the diameter of the cone at the end was  $2\frac{3}{8}$  in. Sheet copper is used for the jacket about  $1/32$  in. thick, which can be rolled to cover the outside with edges hammered over so as to allow for passage of the water. This and the small copper tubes for entrance and exit of the water are brazed with silver solder using the oxy-acetylene flame. The silver solder was made by uniting together metallic silver with half its weight of yellow brass. It is used on copper with borax glass as flux.

The lower electrode can be of carbon or graphite and is separated from the crucible by winding asbestos string or paper at this point.

The influence of temperature, current density, and the separa-

tion of the magnesium from the chlorine evolved at the anode was investigated by a series of experiments carried on in a small porcelain crucible (Fig. 3) containing the fused mixed chlorides. The temperature was determined by a thermo-couple and the anode, which was of carbon, was surrounded by a mica shield to prevent the chlorine from diffusing through the bath. The cathode consisted of an iron wire loop which could be easily varied in the surface exposed. The sketch shows these details.

Changes of temperature were made from  $440^{\circ}$  C. to  $600^{\circ}$  C. and  $700^{\circ}$  C. At the lower temperature the metal can be removed in the spongy form, at the higher temperature the metal melts and is less easy to recover. The current density at the cathode was raised from 50 amp to 500 amp per sq. dcm. These changes made but little difference in the current yield of metal and show that these factors have less

influence on the yield than might have been expected. The metal obtained from some of the previous runs was analyzed and found to contain 98.86 per cent Mg.

The second part of the paper deals with experiments in which **magnesium fluoride** was used as electrolyte (patents of Seward and Kügelgen). A charge was first made up of 72 parts magnesium fluoride, 36 calcium fluoride, to which MgO was added to the extent of 5 per cent of the magnesium fluoride in two portions. The quantity of magnesium produced was insignificant and it could not be recovered. In another experiment 50 parts lithium fluoride, 25 magnesium fluoride, and 25 calcium fluoride were used, but not a trace of metal was obtained. There seems to be a solvent action by such a mixture of fluorides for magnesium, as was actually shown by placing a weighted quantity of metallic magnesium in the melted fluorides; it was found to have lost 40 per cent of weight.

Another series of experiments was made with a double-step process, producing first an **alloy of magnesium**, to be treated then in the second step as anode. Thus, in a bath consisting of chlorides of magnesium with other additions (see above), and using a molten aluminium cathode, it is easy to produce an alloy of magnesium and aluminium. In the second step this alloy would then be made anode in order to recover metallic magnesium at the cathode.

But using a chloride bath, with the addition of some barium chloride, the authors found it difficult, if not impossible, to recover a fair proportion of the magnesium. The authors do not see any special advantage in such a scheme as the current efficiency is no better with aluminium present and the second step of the process is very far from satisfactory.

Alloys of copper are easily made in the same way as the aluminium alloys and show a rather better current efficiency; in one experiment an efficiency of 56 per cent was obtained.

The authors sum up their results as follows: Magnesium can be obtained by electrolysis of its molten chloride in presence of potassium chloride, preferably in a carbon or graphite crucible, but the bath is troublesome and expensive to prepare. The current efficiency may run as high as 60 per cent. The presence of MgO is to be avoided. A small proportion of calcium fluoride tends to consolidate the metal.

In this process changes of current density and of temperature have comparatively little effect unless these changes are very great.

Electrolysis of magnesium fluoride and other fluorides as additions for dissolving oxide of magnesium gave practically no metal and there seems to be direct solution of magnesium in such molten compounds.

Alloys of magnesium with aluminium or copper are easily made by electrolysis with the use of a chloride bath, but they have no special advantage from the standpoint of current effi-

<sup>1</sup> W. Muthmann, H. Hofer and L. Weiss, *Annalen*, 1902, 320 (2), 231.



ciency as compared to the process for making pure magnesium.

The electrolytic decomposition of the alloy containing aluminium for the recovery of the magnesium was unsuccessful.

#### Science and Industry.

The address of the retiring president, Dr. LEO HENDRIK BAEKELAND, was presented in the evening session. It dealt in an inspiring way with "science and industry."

The present age surpasses all previous epochs of history by the intense activity of the human race. All great feats recorded in the history of our race sink to nothingness if compared to what human activity is now accomplishing every day since ignorant, arrogant, emotional, spasmodic efforts are slowly but surely giving place to methodical and persistent work based on exact scientific knowledge.

Whether or not the human race has been made happier, certainly our opportunities for happiness have considerably increased.

Nowhere have the changes of this century been so accentuated as in our industrial enterprises. The two most powerful men of our generation are the scientist and the engineer. Society at large is far from realizing this fact, simply for the reason that the scientist and the engineer manifest their power not as despots, not as cruel tyrants. Their unassuming life is devoted not to slaughter, destruction, or coercion, but to the service of mankind. They do not build useless pyramids cemented with the sweat and blood of overabundant slaves, monuments to vain-glorious despots.

But the modern engineer, applying the principles of science, raises buildings far superior in size and conception than any architecture bygone ages can boast of; edifices incomparably more comfortable, more hygienic, more appropriate than anything built before. He raises those gigantic structures in as many days as it took years to build a temple.

In fact, after a few years, he is ready to pull the same building down, to erect better and bigger ones, to suit advanced conditions, and nobody cares about the name of the architect or the engineer, nor does the builder care himself.

And why should anybody care? The dynamics of the age are producing changes at such a rapid rate that nowadays any building, of whatever size it be, is begun with the feeling that before long it will have to come down to give place to new conditions.

The modern engineer and the scientist realize that much more enduring monuments than stone, brick or bronze will mark the work of this period; they know that the diffusion and application of exact knowledge is shaping the destiny of future generations and will afford more lasting evidence of their efforts than temples or statues; they believe that their work will not count merely for material betterment, but that improved material opportunities created by them will bring forth better people, higher ideals, a better society.

"To put it tersely, I dare say that the last hundred years, under the influence of the modern engineer and the scientist, have done more for the betterment of the race than all the art, all the civilizing efforts, all the so-called classical literature, of past ages, for which some respectable people want us to have such an exaggerated reverence."

"It has been asserted so often by respectable people that science and industry cater only to our material welfare, and have little in common with culture, refinement or moral development. Therefore, I feel compelled to put special emphasis on this side of the question and to insist on the enormity of this error; on the contrary, the development of our industries, or our material prosperity, as well as the study and application of science are the surest and most immediate fore-runners of higher civic ideals, of an improved society, of a better race.

"A clean, properly fed and well-housed individual, who can enjoy the comforts and advantages of modern surroundings, and leads an active, intelligent, productive, self-supporting and

self-respecting life, is certainly more of a man and a credit to his race than were some ancient saints who lived from alms and who spent their life in prayer and inaction, or who, for further edification of their followers, vowed never to change their clothes, nor wash nor shave nor comb themselves; he is more of a blessing to his fellow men than the useless drone who lives on the work of others and gives nothing in return but arrogant presumption based on fortune, rank or title inherited from his father.

"If this be then the age of rational industrialism, of applied science, how then is it that in some industries quality is going down, while prices are soaring upwards?

"Here again it is a noteworthy fact that just such commodities as are produced by so-called scientific industries are sold cheaper and are of better quality than ever before, and this cheapening of price or bettering in quality is almost proportionate to the amount of scientific knowledge involved in their production. Let us take, for instance, the chemical and the electrical industries, both based nearly exclusively on well-developed scientific data.

"In both these groups of industries the chemist or the physicist have had full sway and the engineer has embodied their work in a practical form. Free and rational competition based on intellectual superiority has been their paramount factor of development. Competition based on artificial privileges, like labor unions, tariff legislation, have played only a secondary role. While flour, meat, clothing, and houses were considerably less expensive a hundred years ago than they are now, we find that acids, alkalies, salts, solvents, dyes, and in general almost all chemicals are incomparably cheaper and of better quality than they were in the good olden times.

"In some cases, the changes are remarkable. For instance, a ton of sulphuric acid sells now at the same price as two pounds of the same article were sold about 150 years ago.

"A similar cheapening can be found in many other chemicals, although their demand has immensely increased. Without going to extreme cases, we can state that there has been a steady improvement in most chemical manufacturing processes and that the public at large has had the benefit thereof. The same can be said of the electrical industry.

"Compare this with industries which are still under the sway of the rule-of-thumb, which means the rule of the ignorant, or where competition is based on political protection; you will find that just such rule-of-thumb commodities where science plays no role are those for which the public has to pay the highest price in return for the poorest article. Married men may follow this assertion from butcher's bills to ladies' hats; from house rents to servant girls.

"For the poor chemist, it is almost an irony of fate that his science, by developing the 'cyanide process,' made gold cheaper and thereby reduced considerably the purchasing equivalent of his meager salary. In order to get square he will have to put himself now to the task of helping the engineer in the cheaper production of foodstuffs, or clothing, or take a hand in such economic reforms which may bring about a reduction of rent or may lessen other anomalies.

"Notwithstanding all our progress, it is evident that we live in a transitory stage; next to enterprises and industries embodying the highest intellectual conceptions our century can offer, we find even in the most advanced countries examples of conditions of affairs which seem truly an anachronism.

"To many of you it has happened to visit factories or mills where ignorance and greed seemed the two dominant factors, where the class of men and women employed, not to speak of child labor, seemed to have undergone the full curse of their sordid surroundings. Such places are to be found often where the mental condition of the directors does not enable them to go beyond the conception of size and where the whole tendency has been toward more, more, more, instead of toward better, better, better.

"How different is this from some of our better engineering

and chemical enterprises where everything bears the imprint of a steady effort toward progress and where employer and employed alike seem to undergo the uplifting force of intellectual aims. Such a happy condition of affairs is most likely to be encountered where the head is himself the scientific pioneer who has built up the enterprise.

"Matters are not always so satisfactory where large organizations have gotten into the hands of a board of directors, who know little else of the technical side of the business than that it pays dividends, and for whom the main interesting factor is the value of the shares they own.

"Whenever undertakings are ruled by such a class of men, we must not be astonished if their corporation counsel is more in evidence than their chemists or their engineers. What do they care if certain improvements in their processes might net them 5 per cent more or mean better goods, if on the other hand they know that by a clever trick of law they can extract from the consuming public many times more; no wonder then if they have less time and less mental fitness for a principle of science or engineering involved in a new process than for a conference with eminent law counsel. If they cannot alter nature's atomic weights, they may find a way of improving their invoice weights for the custom house to the detriment of Uncle Sam. I might use for our industries the forceful quotation of Shakespeare in Hamlet about the State of Denmark, as long as corporation lawyers of reputation are paid incomparably better and their services are sought for so much more eagerly than the very best chemists or the ablest engineers.

"This brings to my mind the case of a company which held a charter to supply a certain city with illuminating gas, and which after enjoying a fortune-making monopoly for many years, found one day that special legislation had reduced the selling price of their product. Certain again of being able to upset this law, the company entered in long litigation, but finally, after repeated efforts, had to realize that even its best lawyers could not change matters. From that moment on they began to inquire actively about better manufacturing processes. A friend of mine, who was requested to give his suggestion as to how they could improve their methods, replied as follows: 'Up till now your company has been making *law*—now make *gas* and everything will come out all right.'

"Then again we find that resourceful as the modern engineer or chemist is his power is often simply a tool in the hands of ignorant but cunning men. In fact, our modern laws and society insure better reward for cunningness or slyness than for true intellectuality.

"The very abundance of our natural resources may be partly to blame for this condition of affairs; in other countries, like Germany with comparatively small natural means, competition shapes itself more toward technical perfection. If we want to learn how to reduce what I would call our 'national waste,' then surely our German friends can give us valuable lessons. It is significant, too, that in large German engineering or chemical enterprises, the board of directors is made up mostly of scientifically trained men, engineers, chemists, and physicists."

On the other hand, industries "have sometimes been handicapped by a too one-sided scientific organization; I know of some instances, especially in Germany, where very respectable enterprises have not utilized their available opportunities to the proper extent, because their scientific managers lacked good business sense. I have seen some industrial enterprises much held back by too much red tape and a choking amount of paper wisdom. The most learned man without common sense or practical abilities can accomplish little except disappointments. Here is where the keen business man, with a practical turn of mind, with directness of purpose and good judgment, will every time show his advantages.

"An overspecialized man, whether he be a biologist, a physicist, a chemist, or an engineer may lack the broadness of conception and action which characterizes true great men of many-sided development.

"Then again, quite frequently the real field of usefulness of scientifically trained men is much misunderstood. For instance, it is a common mistake, made even by some engineers and physicians, as well as by business men, to imagine that the main work of the chemist is confined to performing chemical analyses. This conception is about as absurd as to think that the usefulness of an electrical engineer consists in making electrical tests or that the essential work of the merchant is bookkeeping.

"Many a good chemist has been thus prevented from showing his best abilities by the sheer ignorance of those who employed him.

"In the development of some of our industries, nothing has played such an important role as scientific research work."

Dr. Bakeland contrasted the old electric machine of Benjamin Franklin with the gigantic electric installations at Niagara Falls and continued:

"Let me ask a fair question to those who underestimate the value of research: Has that stupendous gap between Franklin's toy and the power companies of Niagara Falls been bridged by anything but by scientific research of the highest order?

"Some of the better educated people in this country begin to understand more and more the necessity of scientific research. Not so long ago, research work was only carried out in the laboratories of universities or in a few highly developed chemical or electrical companies; nowadays we find many intelligently conducted enterprises devoting a considerable annual outlay for systematic research work, where the resources of the chemist, the physicist, and the biologist are used to good purpose.

"Unfortunately, the scope and method of scientific research is difficult to understand for the uninitiated. Some people have only the haziest conceptions on this subject. Some manufacturers, totally unaware of the requirements involved in this work, in a half skeptical way, grudgingly conclude to organize a research department, sometimes as a last resort, to help them through some difficulties; others do it 'to be in style,' and simply to imitate their more successful competitors. Frequently they engage a young man with little experience, who, outside of what he studied in the technical school or at the university, has everything to learn and who besides that is usually entrusted at the very start with the most difficult problems. His salary is none too high and his action is very much restricted; sometimes he is forbidden to study the current practical methods, or so-called 'manufacturing secrets,' and is thus prevented from getting acquainted with the very problems he is supposed to solve. I have seen other cases where the time of the research chemist was filled with odd jobs of every kind. After a while, when practical results are not forthcoming fast enough, the book-keeper confronts him with the list of expenses which have been incurred by his work; naturally some comments are ready at hand how the same money spent on a good salesman would have shown immediate results, and so forth. Things go along that way for a while until the research department is abolished with the recurring remark: 'Research does not pay; we've tried it.'

"In other cases, where some results are obtained, the matter is taken out of the hands of the chemist before he has had time to fairly try and develop it on a large scale. The subject is now entrusted to the superintendent or the foreman, who seldom is a friend of the scientifically trained man, and nearly always resents anything which might diminish the prestige of established practical experience. Like in all new processes, defects are soon shown and in the natural order of things repeated failures and renewed trials on a practical scale are required before there is any possibility of regular utilization. The research chemist is allowed very little intervention at this stage of the work, and after some time, remarks are heard how imperfect the whole thing was 'before so-and-so, the practical man, had his say.' Finally, initial expenses are charged against the research department, and profits credited to the practical man.

"A research department is a very difficult thing to organize



and to run. It is not enough to provide a building and the necessary appliances; it is not enough to provide typewriters, card-indexing systems, and office force, and all the red tape connected with it; it is not sufficient to engage one or more well-behaved university or college graduates with the necessary helpers and to let them work under an orderly businesslike manager. You might as well try to produce masterly paintings by installing an office management and a well-organized paint and brush department, and a library containing all that has been written on the art of painting next to a splendidly equipped studio and then leave out the real artist who will do the painting. Nay, the most important, the almost exclusive factor in a successful research laboratory is the research chemist himself. If he is not a man who has a soul alive with his subject, if he is not enthusiastically imbued with his opportunities, if he is not qualified for his task, not only by scientific training, but specially by a natural gift of discrimination between what is most important in a problem and what is secondary to it, you might as well fill a hall with the marble statues of Greek poets and imagine that they will write poetry for you.

"Then if you find the man who has all the true qualifications, you may still paralyze his action by too much red tape, too much interference in his work. A good research chemist will do more and better work with pots and pans from the '10-cent store' in a shed or in a barn where he is his own master than in a splendidly equipped laboratory where he gets irritated and interfered with by others who do not understand him.

"I sometimes doubted whether it was really worth while for a young man to take up research work single handed when so many people with abundant facilities were at work. What show, for instance, does an organic chemist have in studying a problem for which in Germany some large chemical companies employ hundreds of research chemists? To this I can answer that some of the most striking examples of successful research were the result of privately conducted work with modest means; in fact, I know of several instances where a research chemist who had created himself a reputation by work carried out privately under adverse circumstances, showed disappointing results as soon as he became part of a vast organization.

"Even if you have the best qualified research chemists, do not expect immediate results. Do not forget that problems, appearingly most simple, require considerable time before they are thoroughly studied. Even in successful cases, it may easily require many years before a subject is so thoroughly elucidated that it can be taken up in practice.

"Research is what gives a young man of strong individuality a chance to compete with those big industrial consolidations, the trusts, who, like elephants, look more imposing by their size than by their agility or perfection, and who as that pachyderm have many vulnerable spots, and are just as much handicapped by their lack of flexibility and by their ponderosity. Some steel manufacturers may be unable to think about anything but tonnage, and yet the work of some chemists has already indicated that the quality of steel of the future, or of its alloys, may be improved to such a degree that probably the average steel of to-day will look to our children as brittle and imperfect as pig iron appears to us. Neither should we lose sight of the fact that even to the most exclusive mechanical enterprises, there is a chemical side, although the importance of the latter may not be apparent to the man who is not a chemist.

"Let me give also a warning to such manufacturers who try to secure only by uncompromising secrecy the money-talking end of their industries. As far as my experience goes, exaggerated secrecy is very often an indication of lack of knowledge of industrial feebleness and incompetency; a miser is most of the time a man of small means.

"If the chemists had been holding their results from each other, we would still be in the dark ages of the alchemist. No secrecy, however jealously carried out, can outweigh enlightened research work, protected by wise patent legislation. If our patent laws do not protect enough, then our prime duty

becomes to change them until they answer their purpose as defined by the constitution of the United States. The care with which patent laws are administered is a direct measure of the industrial importance of a country. Piracy cannot flourish, neither on the seas nor in intellectual property, if ethics of justice and equity can be made to prevail.

"Every recorded success of the scientist or the engineer is an additional evidence that ignorant greed and brutal rapacity cannot forever have full sway in this world, and that the rule of the sly and the shy leads to the abortion of progress.

"Furthermore, the results of their work, which bars our 'chance,' 'luck,' or 'happenings,' is their most eloquent language to convince their fellow men that if lawmakers may still think that laws are made or unmade by them in Albany or Washington or Harrisburg, there is at least one law which cannot be amended; at least one law which even the cleverest lawyers cannot make to be interpreted in two different ways; a law which rules all men, large or small, poor or rich, to whatever nation they may belong; a law which rules the dead and the unborn as well as the living; a law which requires no Supreme Court to test its validity; a law that cannot be trifled with, which nobody and nothing can escape; the great unchangeable law of Nature which rules the universe, mocks at men-made statutes and ordinances, and upsets and destroys everything which comes in conflict with her; the rigidly enforced law which tries to teach us our mistakes by suffering, by misery, by industrial or political crisis, by unhappiness, by war, so as to awaken us from our ignorant sleep, to show us our misguided aims, and to command us to prepare a sounder, a happier condition for our children and future generations, while building up, during the trend of centuries, a slowly rising foundation for a higher humanity, a more god-like race."

#### Cheap Power in Pittsburgh.

Prof. F. CRABTREE, of the Carnegie Technical Schools of Pittsburgh, followed with an interesting address on the "Possibilities of Cheap Power in the Pittsburgh District." Since the paper was not printed in advance and contained a formidable array of figures, it is impossible to give here more than a brief outline of the contents. The paper will be printed in full in the *Transactions* of the society.

Professor Crabtree first referred to the wasteful coking process in bee-hive ovens in the Pittsburgh district. From this source alone he estimated 450,000 hp might be developed. The investment would be somewhat high, but the cost of operation would be low. He estimated the cost of the kw-hour for a 100 per cent load factor as about 0.25 cent, and for a 25 per cent load factor as 1 cent.

Professor Crabtree then discussed the utilization of blast-furnace gases which could also be developed into an important source of power in the Pittsburgh district, at an estimated cost of  $\frac{1}{2}$  cent per kw-hour.

The production of power from natural gas was next discussed. The cost was estimated as slightly less than half a cent for a 100 per cent load factor. With producer gas the cost would be slightly higher. The possibilities of low-pressure and mixed pressure steam turbines were also discussed.

In summing up Professor Crabtree thought that the cost of the kw-hour in the Pittsburgh district should be 0.5 to 1.2 cent, and water-power stations cannot do very much better in general.

In the discussion which followed, Dr. Baekeland pointed out that in a great many instances where an electrochemical industry requires a large amount of power, it also requires coal. For instance, in sodium chloride electrolysis, for the production of caustic soda and chlorine, coal is needed for evaporation of the caustic solution. In all such cases the advantages of Pittsburgh deserved careful attention.

#### Induction Furnace Progress.

A review of the progress made in recent years in the design, construction and applications of the induction furnace, both the simple induction furnace type and the combination



furnace type, was given in a paper by Mr. T. ROWLANDS.

**Simple Induction Furnace.**—These are of the Kjellin-Colby design and intended for melting purposes only, as the bath forms an annular channel in a crucible of suitable refractory material, and the crucible is so designed to allow the center leg of the transformer, together with the primary coil, to pass through it (Fig. 1).

The simple induction furnace is running in competition with the crucible process in the manufacture of steel. The comparative cost is given by Mr. Rowlands as follows:

The best practice in the old coke method of melting, as followed in Sheffield crucible process practice, shows that fuel and crucibles alone cost about \$14 per ton, and, in this country, using plumbago and crucibles working with gas producers, the cost is from \$10 to \$11 per ton.

If a medium-sized induction furnace, capable of melting about four tons per 24 hours, pouring only 1000 lb. per cast and working on a high power consumption, is taken for comparison and a high cost is allowed for furnace lining, as follows:

750 kw-hours per gross ton at 0.5 cent per kw-hour.. \$3.75  
Lining per ton..... 1.00

\$4.75

it will be seen that the saving effected on melting for fuel and crucibles only amounts to from \$5 to \$10 per ton.

The assumed figure of a consumption of 750 kw-hours per ton is stated to be high. Moreover, the labor question has not been considered. Excluding the labor for the casting pit, which is about the same in electric and crucible processes, the electric furnace hands are fewer, and it is quite the regular thing for one man and a boy to do all the work on a furnace tapping one ton each heat. The actual saving will be between \$7 and \$13 per ton of ingots.

The regularity of the composition of the steel is another factor in favor of electric melting. Any irregularity in the composition of the steel can be adjusted directly in the furnace before tapping. This, of course, cannot be so finely regulated in crucible practice.

Fig. 2 illustrates the power consumption and power-factor on a charge of over 800 lb.

The simple induction furnace has also been used for the melting of other metals, like nickel and brass.

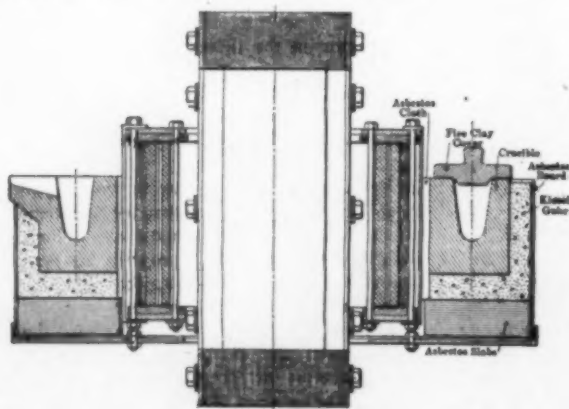


FIG. 1.—SIMPLE INDUCTION FURNACE.

Experiments on nickel melting were made at Niagara Falls with a 60-kw furnace. The molten nickel charge was 108 lb. Details of these experiments are given in Mr. Rowlands' paper. Of special interest is the rapidity of melting down. For the first charge, although the furnace was not very hot, and including delays, it took only 1½ hours, and in the second they commenced charging 50 lb. at 4:12, obtaining a complete melt at 4:22 and teemed at 4:35.

This work was experimental and consequently they were not

working under the best conditions. The furnace was giving a power factor of about 90 per cent, therefore, with an average kilowatt of 48.4; the power consumption for this quantity was at the rate of 325 kw-hours per ton for melting only, which is very good for so small a furnace.

Brass melting in the simple induction furnace has been carried out in England. To overcome troubles with the pinch effect, a special crucible was employed, together with specially constructed coil on the furnace, whereby the electrical conditions could be so changed that at any desired moment most

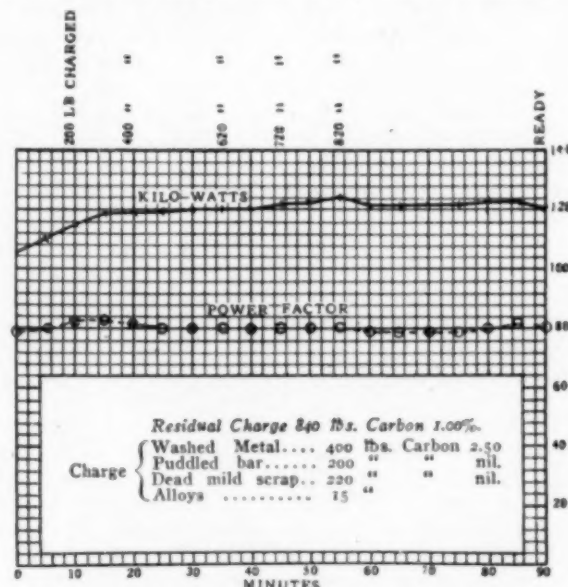


FIG. 2.—POWER CONSUMPTION AND POWER FACTOR. CHARGE 800 LB.

of the current could be carried either by the metal in the bath or by the crucible itself. By this arrangement the crucible is first heated, and, when sufficiently hot, the brass scrap is charged. This soon melts, completing a circuit. The switch is then thrown over, and the metal itself carries most of the current; the crucible, when exposed, gradually becomes cooler, the cooling being visible.

After the first melt was obtained, 112 lb. of brass were charged and melted in about 30 minutes, with a power supply of about 30 kw, and twice the quantity only required 50 kw, melting in the same time. The first heating of the crucible required 42 kw-hours, and took 1½ hours.

The brass produced was remarkably sound, and, when tested against that produced in the ordinary way, showed excellent results.

In addition to this work, other experiments have been carried out on a three-phase furnace, the lining being of firebrick. The result of these experiments shows a power consumption of 18 kw-hours per 100 kg, or about 185 kw-hours per gross ton.

The "pinch" effect is far less intense in the use of three-phase current as compared with single-phase.

**Combination Induction Furnace.**—This is known as the Roechling-Rodenhauser furnace and is used for melting and refining. (See former descriptions in this journal, especially Vol. VI, pp. 10 and 458.)

The author gives a great many details of the operation in a 2-ton, three-phase, Roechling-Rodenhauser furnace. Figs. 3 and 4 are diagrams showing the gradual procedure of the refining operations in course of time. Fig. 3 gives the analyses of slag samples. Fig. 4 the analyses of steel samples.

Details of a run in an 8-ton furnace are next given. The timetable of the various operations, giving also the power in kilowatts at the different times (the voltage varying between 3180 and 4620 and the current between 115 amp and 116 amp) is as follows:

- 12.15 Charged molten Bessemer metal, 440 kw....1st sample.  
 12.50 Charged portion cold scrap, 500 kw.  
 1.50 Charged final portion cold scrap, 600 kw.  
 2.30 All melted, 570 kw.....2d sample.  
 2.50 95 kilos lump lime and 50 kilos roll scale added,  
 580 kw.

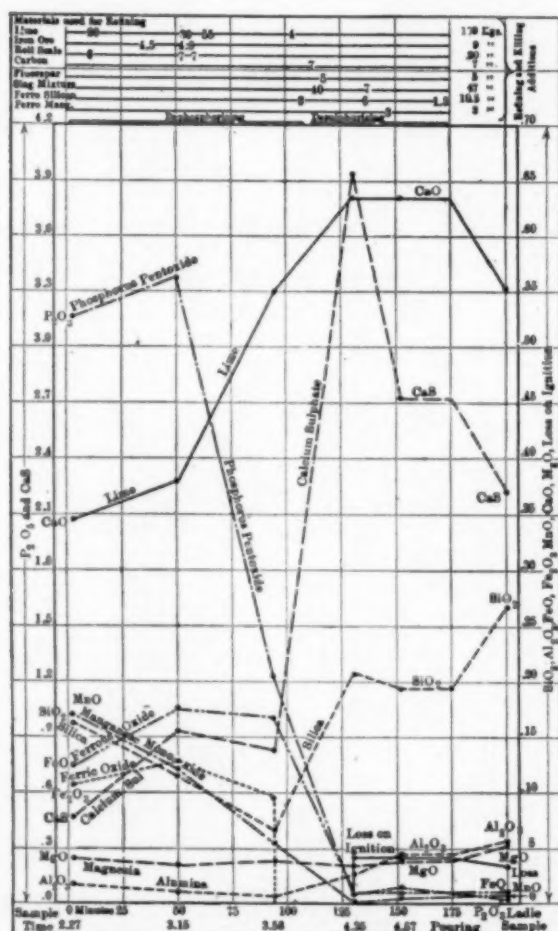


FIG. 3.—SLAG SAMPLES FROM 2-TON, THREE-PHASE COMBINATION FURNACE.

- 3.00 Slag fluid, 580 kw.....3d sample.  
 3.10 160 kilos lime added to stiffen slag.  
 3.30 Removing slag. 45 kilos lime added to stiffen  
 remaining slag. 500 kw.  
 4.00 Removing slag. 395 kw.  
 4.10 Charged 28 kilos carbon and 12 kilos Fe-Si.  
 4.15 355 kw.....4th sample.  
 4.20 100 kilos desulphurizing slag mixture charged.  
 4.25 10 kilos fluospar charged.  
 4.27 Stirred bath.  
 4.32 295 kw.....5th sample.  
 4.35 25 kilos Fe-Si thrown over slag.  
 4.38 Rabbled slag (brown color).  
 4.42 4 kilos Fe-Si and 4 kilos slag added.  
 4.45 Charged 45 kilos Fe-Mn. 295 kw.  
 4.50 Rabbled slag.  
 4.55 Rabbled slag. 450 kw.  
 5.00 450 kw.....6th sample.  
 5.15 Tapped. 400 kw.  
 15 kilos Fe-Si added to ladle when casting....7th sample.

The steel was desired low in carbon, phosphorous and sulphur, and, on that account, extra refining materials were used.

On referring to the timetable and purification curve (Fig. 5) it will be seen that the phosphorus was at its lowest just as soon as the cold metal was melted. The process of desulphurizing

was carried on for another 1½ hours, thereby consuming 800 kw-hours, together with a large quantity of lime and roll scale. The extra cost of these materials amounted to 6½ cents per ton, and the labor would be equivalent to about 20 cents per ton, and power 66½ cents per ton, the total amounting to about 93 cents per ton. The lining would also have produced extra

#### APPROXIMATE AMOUNT OF STEEL, 6 TONS.

Fluxes, etc., Used	Kilos per Charge	Kilos per Ton	at \$1.00 per ton	\$0.05
Lime used (255 + 45).....	300	50	2.50	0.021
Roll scale used.....	50	8 1/3	66.00	0.616
Ferro-Silicon (12 + 25 + 4 + 15)....	56	9 1/3	45.00	0.30
Ferro-Manganese.....	45	7 1/2	5.00	0.10
Desulphurizing slag mixture.....	104	17 1/3	5.00	0.009
Fluospar.....	10	1 2/3	5.00	0.023
Carbon.....	28	4 2/3	5.00	
				\$1.12

tonnage. This waste would not be allowed in this country, but, on considering that high-grade steel is produced, for which a very high price is obtained, the extra cost per pound amounts to 0.04 cent, which is very little.

This must not be regarded as the usual practice, but was due to a lack of care on the part of the workmen.

Not only did the extra oxidizing cost the 6½ cents for the

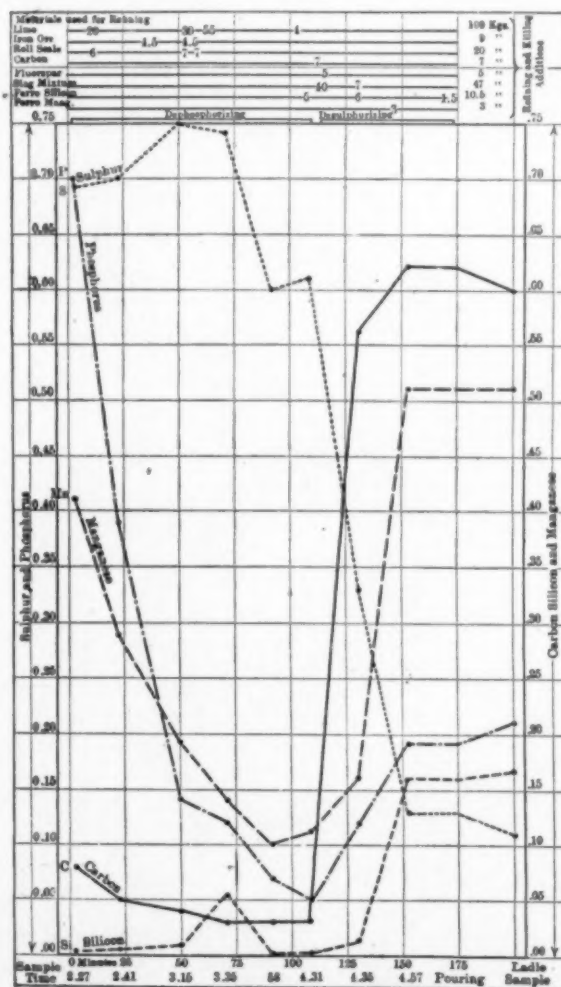


FIG. 4.—STEEL SAMPLES FROM 2-TON, THREE-PHASE COMBINATION FURNACE.

lime and oxide, but, on calculating it out, it was found that the 28 lb. of ferro-silicon was required to take care of it, which is equivalent to 30 cents per ton, and the costs as previously given are really higher than they ought to be.

The total amount of power consumed was 2400 kw-hours, equivalent to 400 kw-hours per ton, using part cold metal.

The costs, then, on this material are as follows:



Refining materials .....	\$1.12
Power, 400 kw-hours, at 5 cents.....	2.00
Labor, three men \$9, at 14% tons per turn..	0.62
Lining .....	0.30

\$4.04

But it has been shown that as much as \$1.23 were wasted on power, labor, etc., to which must be added another 7 cents'

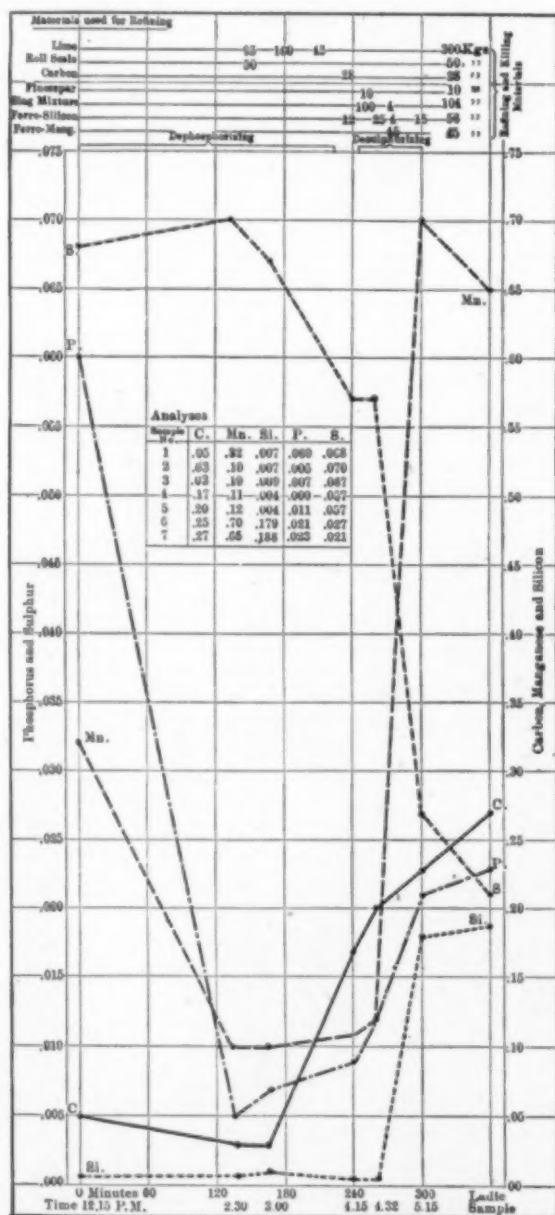


FIG. 5.—STEEL SAMPLES FROM 8-TON SINGLE-PHASE COMBINATION FURNACE.

waste on lining, making a total of \$1.30 to be deducted; therefore, the costs should be:

As observed .....	\$4.05
Less waste .....	1.30

Cost should be..... \$2.75

Finally, an estimate is given of the operation of a 16-ton refining furnace.

As to the results of regular operation of the 8-ton furnace in Völklingen, the following table gives the analyses of 42 consecutive tests:

Basic Steel		Electro Steel			P.		S.		Remarks
P.	S.	C.	Mn.	Si.	P.	S.	P.	S.	
0.049	0.061	1.01	0.33	0.15	0.020	0.022			For heating 4,994 kw-hrs.
0.059	0.065	1.04	0.33	0.18	0.012	0.024			
0.050	0.067	0.79	0.33	0.26	0.012	0.029			It was afterwards found that the lime was running high in sulphur, which would account for the erratic results.
0.060	0.069	0.16	0.33	0.015	Trc.	0.032			
0.054	0.067	0.64	0.89	0.16	0.020	0.016			Most of the high sulphur steels are low in carbon.
0.072	0.079	0.96	0.33	0.084	Trc.	0.014			
0.067	0.067	0.51	0.83	0.13	0.026	0.018			
0.048	0.059	1.20	0.33	0.12	0.015	0.020			
0.055	0.087	0.92	1.06	1.12	0.018	0.020			
0.059	0.079	0.23	0.47	0.019	0.012	0.055			
0.053	0.071	0.57	0.87	0.24	0.018	0.029			
0.052	0.063	1.02	0.39	.18	.016	.018			
0.050	0.067	0.82	0.34	0.096	0.024	.016			
0.058	0.061	0.80	0.37	.054	.021	.020			
0.059	0.065	0.93	0.40	0.16	.020	.018			
0.043	0.089	0.92	0.34	.070	.013	.024			
0.070	0.075	0.18	0.40	.024	Trc.	.038			
0.072	0.069	0.86	0.40	0.10	.023	.019			
0.058	0.081	0.62	0.96	0.16	.024	.020			
0.060	0.067	0.07	0.37	.028	Trc.	.059			
0.056	0.097	0.66	0.82	.066	.023	.032			
0.089	0.091	0.08	0.44	.024	.021	.030			
0.076	0.055	1.00	0.84	0.14	.010	.018			
0.053	0.123	0.10	0.40	.030	Trc.	.038			
0.065	0.079	0.93	0.87	0.11	.024	.020			
0.062	0.071	1.01	0.84	0.19	.020	.024			
0.078	0.073	0.82	0.81	0.11	.025	.027			
0.061	0.067	0.88	0.31	.025	.016	.032			
0.081	0.077	0.59	0.78	0.22	.019	.029			
0.050	0.059	1.06	0.75	0.20	.015	.024			
0.035	0.037	1.10	0.86	0.20	.013	.020			
0.060	0.061	1.10	0.34	.047	.015	.022			
0.065	0.079	0.98	0.34	.023	.012	.014			
0.071	0.048	1.02	0.34	.022	.013	.018			
0.052	0.077	0.83	0.87	0.20	.019	.020			
0.064	0.061	0.92	0.84	0.16	.020	.014			
0.063	0.063	0.83	0.79	0.13	.014	.012			
0.060	0.055	0.92	0.37	0.17	.010	.020			
0.068	0.075	1.00	0.23	0.15	Trc.	.024			
0.072	0.079	1.08	0.28	0.22	Trc.	.016			
0.053	0.065	0.88	0.76	0.13	.012	.020			
0.075	0.071	0.30	0.76	0.22	.014	.029			

#### Ductile Tungsten and Molybdenum.

A paper by Dr. COLIN G. FINK gave the first official information on the latest achievement of the Research Laboratory of the General Electric Company, which has attained success in producing ductile tungsten and molybdenum. This achievement is of utmost importance for the further development of the tungsten-filament lamp.

Tungsten is described in all of the text books as a brittle gray metal and numerous attempts have been made to reduce it to ductile form, as is evidenced by publications emanating from various research laboratories. Roscoe and Schorlemmer, in their latest (1907) edition of their "Treatise on Chemistry," state that "the purest forms of tungsten at present obtainable are hard and brittle and are not ductile, either at ordinary temperatures or when heated."

The metal has ordinarily been obtained in commerce in the form of a dark gray powder usually made by the reduction of the oxide by hydrogen or by carbon. This powder, when obtained in the open market, is generally impure, and is purified by various well-known methods, particularly if the metal is to be used for filaments for incandescent lamps. These filaments are now in commercial use in this country and abroad, and have been made on a large scale. Even in ordinary commercial lamps the filaments are of a degree of purity so high that no impurities can be discovered by the most searching known methods of chemical analysis. Not only is this true, but these filaments are during the course of commercial production exposed to temperatures high enough to drive out by mere vaporization almost any conceivable impurity.

Nevertheless, these filaments show no traces whatever of ductility or even pliability, but, on the contrary, though they are strong enough for mounting in commercial lamps, they are exceedingly brittle and incapable of taking a permanent set.

Attempts have hitherto been made to produce ductile tungsten by various purification processes, but all without success, as by varying the ore from which the tungsten is obtained, as by trying first Wolframite, an iron magnesium tungstate, and then Scheelite, the calcium tungstate. Whichever ore is used it is customary to produce from it the yellow oxide, and additional purity has been sought by repeated precipitations.

Various methods of reduction have been tried, and among other reducing agents used have been hydrogen, carbon, and aluminium. Reduction has also been effected by electrolytic

methods. Since tungsten produced in this way has been so pure that no impurities could be detected by ordinary chemical or physical means, and yet retained its characteristic hardness and brittleness, it has generally been concluded that the metal is entirely lacking in that physical property which is ordinarily called ductility.

The ductile tungsten now produced at the Research Laboratory of the General Electric Company would seem to be a new substance from the point of view of the physical chemist, and for this reason its properties described in Dr. Fink's paper are particularly interesting.

Ductile tungsten is a bright, tough, steel-colored metal, which can be drawn into the finest wire much below one-thousandth of an inch. The tensile strength of the wire increases as the drawing proceeds, or, in other words, the more the metal is mechanically worked, the tougher it gets. In the following table a few figures on the strength of tungsten wires are given. They are the average obtained from a large number of measurements.

Tensile Strength.			
a. Tungsten Wire.			
Mils.			
5.0	2.8	1.5	1.2
Pounds Per Square Inch.			
460,000	480,000	550,000	580,000
490,000	530,000	600,000	610,000
b. Molybdenum Wire.			
200,000	230,000	270,000	.....
260,000	270,000	310,000	.....

The values of tensile strength are given in pounds per square inch and the diameters in mils or thousandths of an inch. A piece of hard-drawn piano wire, tested with the same apparatus, registered, on the average, 507,000 lb., the diameter of the wire being 0.003 in.

Aluminium behaves very similarly. Cast aluminium measures but 17,000 lb. per square inch, whereas the drawn metal has a tensile strength of 36,000 to 39,000 lb. per square inch.

As regards the density or specific gravity of ductile tungsten, the values likewise increase with the amount of working. The values for ductile molybdenum were also determined by Dr. Fink.

Specific Gravity.			Molybdenum.
Tungsten.			
Before Drawing.			
18.81			
After Drawing.			10.02
Mils.			
150	19.30	19.30	
10	19.58	19.64	10.04
1½	19.86	20.19	10.29
		(21.82)	10.32

Martin (1907) found the density of melted tungsten (analyzing 98.96 per cent) to be 16.28; Moissan (1896) and Weiss give the values 18.70 and 18.72 for the brittle metal. As is seen from the table, the density increases very markedly with the amount of mechanical working applied. This same phenomenon is well known in the case of copper; according to Marchand and Scheerer its density is 8.92 and that of rolled and hammered copper 9.95. Distilled zinc has a density of 6.92 and wrought zinc 7.25.

The electrical resistivity and the temperature coefficient of the two metals are given in the next table, determined by the Wheatstone bridge method. The resistance was measured at room temperature and at 170°, employing two oil thermostats.

Resistivity (25° C.)		Temp. Coefficient	
Microhms per Cubic Centimeter.		from 0° to 170° C.	
Tungsten	d 6.2		0.0051
	a 5.0		
Molybdenum	d 5.6		0.0050
	a 4.8		

The values marked d are for hard drawn wires; those marked a were obtained after annealing. These resistivity values are a good deal lower than those given by Gin.

The coefficient for Cu (0° to 160°) is 0.00445 (Reichardt). The hardness of both W and Mo depend very much upon the amount of mechanical working the metals have undergone and upon the presence of impurities.

Chemically, the two ductile metals behave similarly in most respects. The drawn wire retains its luster almost indefinitely. Both metals are readily attacked by fused oxidizing salts, such as NaNO<sub>3</sub>, KHSO<sub>4</sub>, and Na<sub>2</sub>O<sub>2</sub>. Acids (HCl, HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>) attack tungsten very slowly, but molybdenum rather steadily. Dr. Fink has heated fine-drawn tungsten wire in a mixture of chromic and sulphuric acid for 16 hours, but could detect only a very small loss in weight.

Original weight, 16.7330 grams; after 16 hours, 16.7329 grams.  
" " 1.3638 " " 14 " 1.3635 "

In conclusion Dr. Fink states that this work was carried out at the Research Laboratory of the General Electric Company, at Schenectady, N. Y., and that naturally a number of chemists and research men have been active in it, foremost among whom is Dr. Coolidge.

#### Treatment of Cobalt-Nickel Ores.

A paper by Mr. CAMILLO C. CITO, of the Irvington Smelting & Refining Works, of Irvington, N. J., described a new process for the treatment of cobalt-nickel ores, rich in silver and arsenic, by combined melting and electrolytic operations.

The so-called Canadian cobalt ores have attracted the attention of investors and refiners since their discovery in 1903 because of their unusual richness in silver. By 1907 the yield of silver from these ores amounted to 5 per cent of the entire world's supply, but this was obtained mainly from the richest veins, the lower-grade ore being thrown aside to await the development of an economical method of extraction.

Besides silver these ores contain nickel, cobalt, and arsenic, the latter element often being present to the extent of 40 per cent. The arsenic has proven a serious obstacle in the working of the ore, since, if wasted and the arsenic allowed to escape, it endangers the lives of the community besides entailing a loss of silver equal to about double the amount of arsenic removed. If these volatilized products are condensed expensive chambers must be provided and the condensed products again separated.

The mines are situated in northern Ontario, Canada, to the east of Lake Superior, and with the center in Cobalt City.

According to the eighteenth annual report of the Bureau of Mines, Ontario, 1909, Vol. 18, Part 1, the mining camp consists now of 40 different mines, which shipped from 1904 to 1907 inclusive, a total of 48,544 tons of ore. The rapid increase in the output is best shown in the fact that in 1908 alone the total shipments amounted to 25,362 tons.

The more important mines of the district are at present: La Rose, Nipissing, O'Brien, Drummond, Crown Reserve, Buffalo, City of Cobalt, Temiskaming, Right of Way, Temiskaming & Hudson Bay, Trethewey, etc. They all ship between 500 and 5000 tons of ore a year.

The rock consists mostly of greenstone, crossed by granite of a later formation. The ore deposits are found in this granite, partly mixed with quartz, feldspar, pyrites, magnetite, and chlorites. The veins differ widely as regards thickness, as well as disposition of the mass; they contain chiefly the following minerals: Argentite, pyrrargyrite, smaltite, cobaltite, erythrite, niccolite, gersdorffite, chloantite, arsenopyrite, etc.

**Experiments.**—The idea suggested itself to try out first the practicability in this special case of all the methods, either wet or dry, already in use for the treatment of similar silver ores. Mr. Cito mentions only briefly these experiments, as all gave more or less unsatisfactory results.

After many failures he succeeded in finding a combined method consisting of a melting process followed by an elec-



trolytic separation. The process is already patented, or filed for patent, in all the principal countries. (U. S. A. Patents 949,058, 949,059, 949,261).<sup>1</sup>

The experiments described below were made with an ore of the following composition:

- 4.12 per cent silver (1200 oz. per ton).
- 19.6 per cent arsenic.
- 11.2 per cent cobalt.
- 5.7 per cent nickel.
- No lead.
- No copper.
- 0.5 per cent antimony.
- 18.5 per cent iron and alumina.
- 11.0 per cent silica.
- 1.7 per cent calcium oxide.
- 1.9 per cent sulphur.

**I. Experiments in Mechanical Concentration.**—The ore was ground and passed through a sieve of 200 meshes per square centimeter. Fifty kilograms of ore gave in this way

46 kg fines = 92 per cent.

4 " metallics = 8 " "

The distribution of the principal metals was the following:

	Fines.	Metallics.
Silver.....	2.3 per cent.	25.0 per cent.
Arsenic.....	18.5 " "	32.5 " "
Cobalt.....	11.5 " "	8.3 " "
Nickel.....	5.8 " "	5.1 " "

As far as the principal metal, silver, is concerned, it can be seen that about half of it is concentrated in the metallics. The fines, however, are for the same amount poorer and their further treatment, therefore, less profitable.

**II. Wet Processes.**—The leading idea in these experiments was either to leach the silver out of the raw or roasted ore and collect nickel and cobalt and arsenic in the residues, or to dissolve first nickel-cobalt and arsenic and to recover the silver from the slimes.

All the wet processes known as being in practical use were tried with both raw and roasted ore, at different temperatures and with varying concentration of the dissolving agents, as follows:

(a) *With raw ore:* Leaching with potassium cyanide, hydrochloric acid and sulphuric acid.

(b) *With roasted ore:* Leaching with sodium chloride (Augustin process), sodium thiosulphate (Patera process), sodium-copper thiosulphate (Russel process), potassium cyanide (cyanide process), acids (hydrochloric and sulphuric acid), magnesium chloride, ammonia.

The solutions as well as the residues obtained in the enumerated experiments have been analyzed as far as the principal metals (silver, nickel, cobalt, arsenic) are concerned. Although the experiments were carried out on a small scale, and therefore the conditions for complete reactions were favorable, not in a single case was a satisfactory result obtained. With both raw and roasted ore the silver, on the one hand, did not dissolve completely, even with large quantities of solvent; nickel, cobalt, and arsenic, on the other hand, when they ought to have dissolved, remained to a large percentage in the residue, especially arsenic, while considerable quantities of silver passed into solution.

The working up of the solutions and the residues would, therefore, lead to a great many intermediate products and would become very complicated.

**III. Dry Processes.**—(1) **Roasting Experiments.**—The object was:

(a) To drive out the arsenic by roasting the ore alone or with certain fluxes.

(b) To transform the silver into a soluble compound with the aid of certain fluxes, and to extract it by one of the methods before mentioned.

For the experiments on a small scale the fines passed through

the 200 meshes per square centimeter were used; the roasting was done in a small muffle furnace.

When roasting without fluxes at a steadily increasing temperature the ore was dead-roasted after 8 hours. The charge showed a loss of 8 to 12 per cent of its original weight, corresponding to a loss of silver of from 15 to 24 per cent, while the contents of arsenic changed but little.

In order to prevent the formation of arsenates the same fines were mixed with different amounts of powdered charcoal and roasted for six hours. The roasting losses in these cases varied from 5 to 10 per cent. At the same time the loss of silver varied from 20 per cent and 30 per cent, with only a trifling loss of arsenic.

With the idea of eliminating the arsenic in the form of sulphide of arsenic, the fines were mixed with raw pyrites and roasted at a slowly increasing temperature for 8 hours. The loss in the weight of the mixture amounted to 8 per cent, according to a loss of 6.3 per cent silver and 7 per cent of arsenic.

For a chlorination process the same fines as before were first dead-roasted, then mixed with charcoal powder and roasted a second time in order to decompose the arsenious salts; this product was heated a third time at a dark red heat with a certain amount of sodium chloride. After this third treatment 22 per cent of the original arsenic contents were eliminated, but at the same time there was a loss of 35 per cent of the silver.

The products of these roasting experiments were used for testing the different wet methods mentioned above.

The results obtained when roasting the fines in small quantities were fully confirmed by an experiment on a commercial basis; 9,060 kg of ore was given a preliminary roasting in a reverberatory furnace, then mixed with galena ore and roasted a second time in order to get the material in a lumpy form for subsequent treatment in the blast furnace.

The ore contained 3.77 per cent silver, equal to 341.56 kg in the whole charge. The roasted material weighed 8,045 kg, assaying 3.42 per cent, or 275.13 kg of silver. Therefore the loss of silver in this roasting amounted to 66.43 kg, or 19 per cent of the original amount, not including the contents of the flue dust.

At the same time it was ascertained that only a small amount of the arsenic was eliminated. The original 9060 kg of ore contained 18.9 per cent of arsenic, equal to 1712 kg, while in the roasted 8045 kg still 19.2 per cent, or 1545 kg, of arsenic were found, corresponding to a loss of 167 kg, or 9.8 per cent of the original amount.

#### (2) Melting Process.

(a) **Melting with Lead Fluxes.**—The ore which had been roasted with charcoal and galena, as described above, was melted in a blast furnace with the usual fluxes, including some lead-bearing material, producing metallic lead, a speiss, a matte and a slag. Although the furnace was running well, the quality of the products was quite unsatisfactory. The lead was very brittle, the speiss could not be cleanly separated from the matte by mechanical means, and the slag was not fluid. The distribution of the principal metals in these four products was as follows:

	Lead, Per Cent.	Speiss, Per Cent.	Matte, Per Cent.	Slag, Per Cent.
Silver .....	1.78	0.32	1.52	0.013
Lead .....		4	43	3.3
Copper .....		0.8	9	Trace
Arsenic .....		34	0.3	
Nickel-Cobalt .....		41	5.5	1.5
Sulphur .....		4	21	

Of 299.76 kg silver contained in the original charge (including the fluxes), 275.03 kg were recovered in the four products given above. The loss of silver amounts therefore to 24.73 kg, equal to 8 per cent, not including the flue dust. If no account is taken of the loss in the roasting process, the output in silver in the blast-furnace operation is fairly satisfactory. The accumu-

<sup>1</sup> See our March issue, page 148.

lation of nickel and cobalt in the speiss and matte, however, is deficient; indeed, of 1246 kg of nickel and cobalt in the original charge, only 319 kg appears in speiss and matte, corresponding to 25.6 per cent, by far the greater part of these metals passing into the slag.

From the above it results clearly that this kind of ore cannot be melted successfully in a blast furnace with a lead charge, even without considering the loss of silver which already occurs in the roasting operation. Nickel and cobalt and especially silver are found in all the four products of the furnace in such amounts that the further treatment of these would be very complicated and uneconomical.

(b) **Melting with Copper Fluxes.**—In order to avoid the many products (lead, speiss, matte, slag) which result from melting these ores with lead fluxes, a great number of experi-

even small volatilization of arsenic is always accompanied by considerable loss of silver, and, secondly, it is highly important to reduce the escape of the extremely dangerous arsenical fumes to a minimum.

After a number of failures it was found that in order to be successfully worked up as anode, the alloy had to contain the different metals in certain definite proportions.

The amount of copper added has to vary according to the amount of silver, arsenic, nickel and cobalt present in the ore.

As far as the principal metals are concerned, the ores run as follows:

Silver .....	300—10,000 oz. per ton.
Nickel and cobalt .....	10—30 per cent
Arsenic .....	5—40
Lead .....	None.

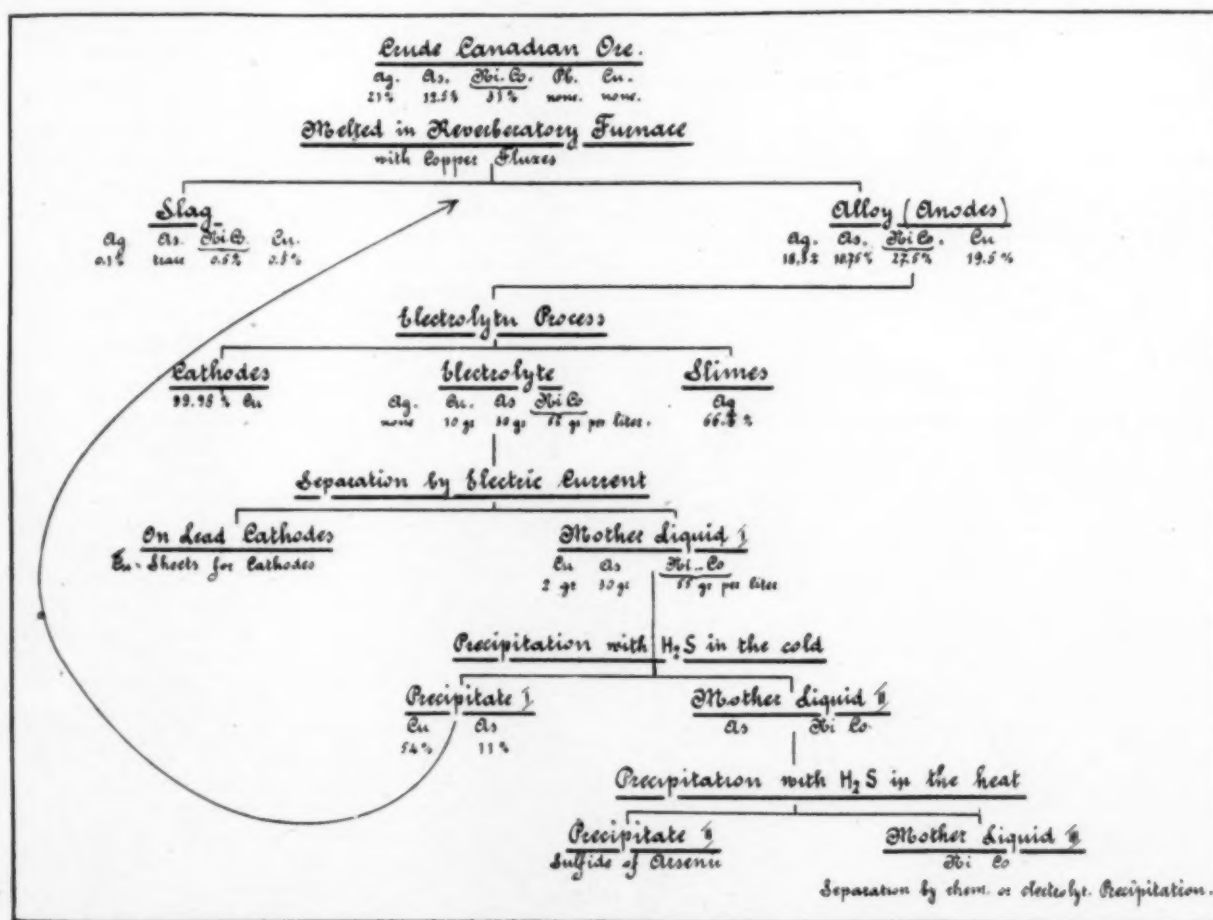


DIAGRAM OF PROCESS FOR THE TREATMENT OF COBALT-NICKEL ORES.

mental meltings with copper fluxes were carried out with the intention of producing an alloy containing all the silver, nickel and cobalt and a slag as poor as possible in these metals.

It should be expected that, owing to the small amount of sulphur in the ore, no matte would be formed. The absence of lead is likewise of the utmost importance, and the greatest care is taken that, contrary to the usual processes of treating silver ore, this metal does not enter the material.

To avoid silver losses by roasting, only the raw ore was taken into consideration for these experiments, because it is not possible, as shown in the before-mentioned roasting experiments, to drive out the arsenic to any extent by roasting without losing more or less silver.

The final object of this part of the research consisted in producing an alloy which could be worked up as an anode in an electrolytic bath. At the same time this alloy had to take up as nearly as possible all the arsenic, because, first, as shown before,

The treatment of the ore consists of two operations, viz.: 1, the smelting process; 2, the electrolytic process.

**A. The Smelting Process.**—The ore is smelted without any preliminary treatment, such as roasting, etc., in a reverberatory furnace with a calculated quantity of copper and the necessary amount of the usual fluxes.

The addition of the copper practically eliminates arsenic from the fumes in the smelting process because the arsenic is absorbed by the metallic copper.

Only two products result from this smelting process:

(1) *An alloy*, containing, besides copper, all the silver, nickel and cobalt, and nearly all the arsenic. On account of the subsequent electrolytic refining of this alloy, it is important that the different metals composing it, as mentioned before, should be present in a certain proportion, viz., it is necessary that: (a) The percentage of copper be two-thirds of that of the nickel and cobalt, but (b) at least the same as that of the arsenic, and



preferably not less than the silver. The alloy is tapped from the furnace directly into the anode molds. Besides the alloy there is obtained:

(2) A slag, containing a very low percentage of silver, nickel and cobalt. This slag can be used to advantage as a flux in the blast furnace, where the last traces of the metals can be easily recovered.

For instance, when melting 174 lb. of ore with the proper amount of copper and the necessary fluxes, no fumes were visible. The result of the melting is to be seen in the following table:

	Canadian ore before melting 174 lbs.	Alloy after melting 195 lbs.	Slag after melting 56 lbs.
Silver .....	6200. oz. p. ton	5500. oz. p. ton	20. oz. p. ton
Arsenic .....	12.5 per cent	10.75 per cent	Trace
Nickel and cobalt.....	31. per cent	27.5 per cent	0.5 per cent
Lead .....	None	None	None
Copper .....	None	19.5 per cent	0.5 per cent
Iron .....	3.5 per cent	0.5 per cent	7.6 per cent
Sulphur .....	1. per cent	1.2 per cent	
Insoluble .....	9.64 per cent		

All the valuable metals pass into the alloy; only a small fraction of the silver appears in the slag (29 oz. per ton). The data concerning the arsenic are noteworthy: 174 lb. of raw ore containing 12.5 per cent arsenic, after the melting, yields 195 lb. of alloy containing 10.75 per cent arsenic; allowing for small errors in the analysis, it results clearly from these figures that in melting practically no arsenic has escaped in the fumes.

**B. The Electrolytic Process.**—The different metals of the alloy are separated from the anode in an electrolytic bath by electric current.

A great number of experiments were carried out with alloys of unvarying composition in small electrolytic baths, in which the utilized anode surface reached 7 square decimeters. Later on, the electrolytic process was tried out in large baths with a utilized anode surface of  $\frac{1}{2}$  square meter; the results obtained here were identical with those in the small baths.

The electrolyte consists of a solution of copper sulphate in water, which during the whole electrolytic process contains at least 10 grams of copper and 5 grams of free sulphuric acid per liter.

The cathodes are sheets of pure copper.

The density of the electric current has to be regulated according to the composition of the anodes and electrolyte and according to the temperature.

The temperature is kept advantageously at 60 deg. Cent. or higher, and is otherwise regulated by the percentage of arsenic in the anodes.

In case proper conditions prevail, viz., if the electrolyte as well as the temperature and the electric current correspond to the composition of the alloy, the following results will be obtained:

(1) The copper contained in the anode is deposited in the form of pure electrolytic copper on the cathode.

(2) The silver of the anode is quantitatively precipitated in the slimes.

(3) All the nickel and cobalt dissolved from the anode remains in solution in the electrolyte.

(4) At the proper temperature the larger part of the arsenic is found dissolved in the electrolyte, the balance going into the slimes with the silver.

**Further Treatment of the Different Products of the Electrolysis.**—This is being done in three steps.

(1) The copper deposited on the cathode is exceedingly pure. A determination of the copper yielded 99.98 per cent Cu. The great advantage of this simple, as well as cheap, process is obvious, as the copper originally added as a flux is recovered as a commercial product.

(2) The slimes, of course, are rich or poor according to the percentage of silver in the anodes. Under all circumstances the slimes contain all the silver of the anode, as neither in the cathode nor in the electrolyte can traces of silver be determined. The small quantities of arsenic which go into the slimes, to-

gether with the silver, can be easily removed by a light roasting or dissolving process.

For instance, an ore, originally containing 600 oz. silver per ton, 19 per cent arsenic and 17.5 per cent nickel-cobalt, yielded slimes of 12,000 oz. silver per ton; while the slimes of another ore that ran 3500 oz. silver per ton, contained 24,500 oz. silver per ton.

These silver slimes can, without any difficulty, then be refined in the test furnace by the usual cupellation process. Also, here the advantage of the process can be clearly seen, as the silver, being the principal component of the ores, is extracted in a very simple as well as safe and especially rapid way.

(3) The electrolyte containing the whole of the nickel-cobalt and the larger part of the arsenic can be brought up to the following concentrations:

Silver.....	None.
Copper.....	10. grams per liter.
Nickel-cobalt.....	55. grams per liter.
Arsenic.....	30. grams per liter.

By using insoluble anodes almost all the copper contained in the electrolyte can be precipitated as pure copper on thin lead cathodes. The density of the current has to be lowered according to the decrease of copper in the solution, and at the same time the temperature has to be raised. With a current density of 150 to 200 amp per square meter and a temperature of 80 deg.-90 deg. Cent., the copper in the electrolyte can thus be reduced to about 2 grams per liter.

The precipitated copper is very smooth, and can easily be detached from the lead sheets and used as cathodes in the regular electrolytic baths.

The balance of the copper is advantageously precipitated by sulphuretted hydrogen in the cold, whereby very little sulphide of arsenic is formed. This copper product can be used over as flux.

All the arsenic can then be precipitated by sulphuretted hydrogen upon heating as practically pure sulphide of arsenic, which can be placed on the market as such.

Nickel and cobalt can now be recovered, together or separately, by any of the methods usually employed, such as electrolysis or by chemical precipitation.

The principal advantages of this process are:

(1) Utmost simplicity and consequently very low running expenses.

(2) Great rapidity in extracting the most important metals, and especially the silver.

(3) Remarkable safety by reducing to a minimum the danger from arsenic vapors which are liable to develop in the treatment of such material containing a large amount of arsenic.

(4) Direct output of the principal metals, limiting at the same time the forming of by-products.

In contrast to the above-described process the methods used at present for the direct production of silver from these ores seem to yield far less satisfactory results.

According to the eighteenth annual report of the Bureau of Mines of Ontario, 1909, Vol. 18, Part I, "there were three reduction plants in Ontario treating ore from the mines of Cobalt last year, namely, those of the Canadian Copper Company, at Copper Cliff; the Deloro Mining & Reduction Company, at Deloro, and the Coniagas Reduction Company, at Thorold. Through these works there were passed an aggregate of 6958 tons of ore containing 11,658,008 oz. of silver, of which 8,972,958 fine oz. were recovered, the remainder, 2,685,050 oz. = 23 per cent, being contained in the *speiss* product reserved or exported for further treatment."

Considering, moreover, that probably a great part of the silver produced referred to in this report was shipped in the form of nuggets containing 75 to 85 per cent of silver, the output appears even less favorable, while in the process which forms the subject of this paper a yield of fine silver of 98 per cent of the contents of the ore can be directly obtained. The paper was briefly discussed.

### A New Radiation Pyrometer.

A paper by Mr. C. E. FOSTER, of the Taylor Instrument Companies, gave a description of a new radiation pyrometer.

For the measurement of the very high temperatures met with in electric furnace processes, and also in open hearth work, there is practically no instrument which can give any satisfaction, except those of the radiation type. There is also another field of temperature measurement which can only be handled by the radiation pyrometer, and that is what may be called a continuous furnace process. By this is meant any process in which the furnace is maintained at a steady temperature, while the material under treatment is fed into and out of the furnace in a more or less continuous manner. Accordingly, the temperature of the material will vary with the time it remains in the furnace. It is obvious that in such a case, even though the temperature may be low, the mere measurement of the furnace temperature by means of a thermo-couple will not give reliable results. What is wanted is the actual temperature of the material as it issues from the furnace.

To make successful measurements in either of these cases it is generally necessary that the operation of the pyrometer be very simple and quick. The more complications there are attached to its use, the more the likelihood of errors and unsatisfactory readings, because the conditions obtaining are not conducive to calm and accurate adjustments.

These considerations practically confine the use of the purely optical pyrometer to the laboratory, or at any rate, to the laboratory staff. With a view to providing a radiation pyrometer which is practically "fool-proof" and requires no manipulation, Mr. Foster has designed his fixed focus instrument. In this instrument simplicity has been the governing feature. At the same time its construction avoids errors in calibration and use.

Fig. 1 shows the instrument being used to measure the temperature in a furnace used for continuous processes and the user is pointing it so as to measure the temperature of the piece of steel about to be removed from the furnace.

Fig. 2 shows a diagram section of the tube. At the front end is a diaphragm EF, while at the opposite end is a concave mirror C. The radiant heat from any hot body, such as AB, enters the opening in the diaphragm and a fixed proportion of it strikes the mirror. It is then collected at a focus D. The arrangement is such that there will be, at D, a focused heat image of the diaphragm, filled with the radiant heat from the hot body AB. At D is placed the sensitive part of the instrument, and this is the hot junction of a thermo-couple.

Looking at the diagram in Fig. 2 it will be seen that a body covering any larger angle than AGB would not be able to radiate any more heat to the mirror C. Any extension of the hot body beyond the limits indicated by the dotted lines GA and GB would only be able to radiate heat to the walls of the tube and these are made non-reflecting. The dotted lines in the diagram define a cone whose apex is at G. For any given hot body the maximum working distance will be a fixed multiple of the diameter or other smaller dimension of the body. Any working distance less than this maximum will simply result in the outer edges of the hot body being out of the measurement. In all cases the action is just as if the hot body were actually at the diaphragm EF.

The instrument is designed so that the mirror throws on to the thermo-couple junction at D a focused image of the aperture EF. This fact also supplies the reason for the name "fixed focus." The position of the apex G is shown on the outside of

the pyrometer tube by the metal ring which carries the fixing stud and nut. For the sake of convenience, the proportions of the hot body to the working distance are not shown to scale in the diagram. In the standard tube the actual proportion is 1 to 10.

The thermo-couple is composed of two very small wires of different alloys. These are joined together at one end. Their other ends are joined to a suitable electrical circuit including a flexible cable and an indicating millivoltmeter. The radiant heat is concentrated upon the common junction of the two alloys with the result that this junction is heated above the temperature of the junctions of these two alloys to the rest of the circuit. This heating sets up an electro-motive force and as a result a current flows through the millivoltmeter proportional to the heat concentrated, that is, proportional to the temperature of the hot body under examination.

The whole of this sensitive thermo-couple is contained within the pyrometer tube and, therefore, the indications of the instrument are independent of the general air temperature or that of the tube itself. Any change in this temperature will affect the thermo-couple as a whole and the excess temperature of the common or hot junction will depend only on the radiant heat concentrated upon it.

The calibration of the indicator scale is based upon the well-known Stefan-Boltzmann law. This law has received abundant support, both theoretical and practical, and the fixed-focus pyrometer follows it very closely. At the same time the actual calibration of the whole outfit is based on comparison with certain standards, both instruments being pointed at a high temperature furnace so that any departure from the Stefan-Boltzmann law is taken into account in the calibration and does not appear as an error.



FIG. 1.—FIXED-FOCUS PYROMETER IN USE.

Two standard scales up to 2400° Fahr. and up to 3200° Fahr. respectively are being made, and this latter is more particularly suitable for work upon the open-hearth furnace. Of course, there is no difficulty in scaling the instrument for still higher temperatures, as it has no upper temperature limit.

The efficiency of the receiving tube is very high and, accordingly, the indicator is made of a very robust moving-coil pivoted type. It does not require accurate levelling in use, nor is there any clamping or other manipulation necessary. In fact, the whole instrument is always available for immediate tempera-



ture measurement. It has simply to be pointed at the hot body and a steady reading is obtained in about 15 seconds. Each receiving tube is provided with a stud and wing nut mounted upon the center ring so that it can be clamped to any support for use permanently in one place. In this way it can be arranged so as to show the temperature of each billet as it comes from a billet heating furnace.

In the discussion which followed, Mr. Foster said that the

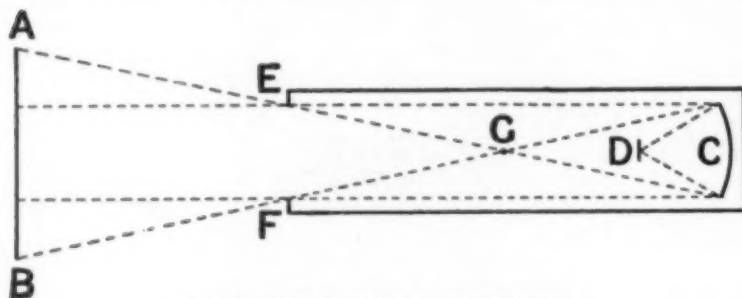


FIG. 2.—DIAGRAM OF THE RECEIVING TUBE.

instructions to the user are simply that the distance of the instrument in use from the furnace, the temperature of which is to be measured, should be less than a certain length, depending on the dimensions of the instrument.

#### Dry Cells.

The first paper presented at the Saturday session was a paper by Mr. D. L. ORDWAY, of the National Carbon Company, of Cleveland, on "The Evolution and Present Status of the Dry Cell."

The author first summed up the chief electrical characteristics of the dry cell and mentioned that the short-circuit current is often used as a measure of the "service capacity" of a cell. But this is quite wrong. As is evident from some tests of new and old cells given by Mr. Ordway, there exists practically no relation between short-circuit current and amp-hour capacity.

The decisive test of the quality of a cell should be amp-hour capacity or watt-hour capacity, but much depends on the way in which the cell is discharged. If a cell is discharged through a contact resistance, the value of which is chosen different in different tests, the discharge curve drops, of course, more rapidly the lower the resistance. The most abrupt drops of voltage are at the beginning and at the end of a discharge; these are due to different causes, which were discussed.

But while these curves of continuous discharge are of considerable theoretical interest, they are of small value in practice, since dry cells are generally used in practice on intermittent discharge. According to the kind of service, the use of the dry cell should differ, for instance, with respect to the number of cells in series and in parallel. In ignition service, more than one set of cells in multiple is advantageous, while in light service, like telephone service, it is a positive disadvantage to operate more than one set of cells in multiple.

According to the kind of service desired, the form of intermittent discharge by which the cell is to be tested, should be arranged. In tests of dry cells it is important to pay attention to the temperature. Only tests made at the same temperature should be compared.

As the principal uses of dry cells are in ignition service and in telephone service, special tests have been worked out for both purposes both by the manufacturers and consumers. These commercial tests are reviewed in detail in the paper, which will be printed in full in the *Transactions* of the society.

The paper was briefly discussed by Mr. C. Hering.

#### Electrolytic Separation of Oil from Condenser Water.

A paper by Prof. H. M. GOODWIN and Mr. RIDSDALE ELLIS, of the Massachusetts Institute of Technology, deals with "the separation of oil from condenser water by electrolysis."

The investigation was suggested by an English patent (10,874

of the year 1902) of Davis and Perrett, who run the condenser water to be purified in a circuiting path through a vessel fitted with iron electrodes. They add to the water "at its inlet and as required a small and regulated quantity of ordinary clean water or of carbonate of soda or of potash dissolved in water." The small particles of oil were said to become "entangled with the detached minute particles of iron or other metal used for electrodes."

It is then possible to remove the oil from the water by filtration. "The oily particles are not oxidized or decomposed to any appreciable degree, and the oil can be recovered in the usual manner from the scum that forms on the surface of the water in the vessel or from the precipitate on the filter cloths or in the settling tanks."

The effect of the current is, therefore, to so modify the character of the emulsion that the oil particles may be readily separated from the water by filtration. The process differs from other electrical methods which have been devised for the purification of ordinary water (not only feed-water) in that an electrolyte is here added to give conductivity to the water. In most other cases

the impurities in the water form the electrolyte and the flocculant precipitate formed from aluminium or iron electrodes acts as clarifying agent. Of the other methods employed for the separation of oil from water the authors mention the following:

(a) Gravity and mechanical separation, as by a baffle plate separator which Carty has shown will separate 75 per cent of the oil fed to the cylinder of an engine,

(b) Addition of de-emulsifiers which destroy the film on the surface of oil particles, thus permitting them to coalesce.

(c) Filtration through various media.

When pure oil is violently agitated with pure water no permanent emulsion is produced, for if the mixture be allowed to stand, a complete separation of the two constituents takes place. The minute oil globules gradually rise owing to their lesser specific gravity and coalesce as they come into contact with one another. If, however, a small amount of emulsifying agent be present a portion of the oil will be permanently emulsified, i.e., distributed through the water in a so minutely divided state that it cannot be separated from the medium by gravity or ordinary filtration.

The role played by the emulsifier is to produce a film of solid matter over the oil globules so that coalescence in contact is prevented. The more common emulsifiers are such organic substances as soap, gums, proteids and also certain colloids such as ferric-hydrate. Ramsden has shown that exceedingly small amounts of proteid matter are sufficient to effect emulsification. Electrolytes as a class do not act as emulsifiers, although sodium carbonate or hydroxide will emulsify oils of fatty acids owing to the formation of soap films.

Certain solid substances, like lime and clay, also act as partial emulsifiers, forming so-called quasi-emulsions. In this case the substance is retained in suspension by association with the minute solid particles rather than being completely enveloped by a solid film. The emulsifying power of solids depends very largely on the minuteness of the particles.

No definite magnitude can be assigned to particles forming permanent emulsions, but generally speaking they are sufficiently large to be visible under the microscope. Their size, therefore, distinguishes them from colloidal suspensions and the still smaller particles forming true colloidal solutions. Although colloidal molecules are believed to be large, as indicated by their molecular weight, small osmotic pressure, rate of diffusion, etc., they are still so small as to be beyond the resolution of the best microscopes.

Colloids and emulsions possess the common property of migrating under the influence of a potential gradient, and are, therefore, electrically charged. Two distinct hypotheses have been proposed to account for the existence of the charge asso-



ciated with them, which is usually negative in character, as shown by the direction of migration of the particles to the anode. The first hypothesis is due to Coehn<sup>1</sup>, who states the general proposition that a difference of potential is always produced at the junction of two dissimilar media, when brought into contact, that one assuming a positive charge which possesses the higher dielectric constant. This readily explains why water with its abnormally high dielectric constant of 80 is positively charged with respect to almost all particles suspended in it. The positive charge observed on such substances as colloidal ferric-hydrate seems an exception to this rule.

The second hypothesis assumes the charges to result from association or absorption of negative or positive ions with the colloidal or emulsified particles or an ionization of the colloidal molecules themselves (see Noyes<sup>2</sup>, page 99).

The present authors do not attempt at present to decide the relative merits of these two hypotheses. The fact that the emulsified particles are electrically charged and that this charge which undoubtedly is largely instrumental in preventing them from separating under the influence of gravity from the medium containing them is the important thing to be here recognized.

The authors prepared their emulsions from distilled water and a pure valve cylinder oil. The results of their experiments are summed up as follows:

The oil particles in the emulsions investigated varied in diameter from about 0.0006 cm to 0.00006 cm and are negatively charged, as shown by their migration to the anode under the influence of a potential gradient.

The addition of dilute solutions of sodium carbonate does not produce de-emulsification.

Partial de-emulsification of oil (about 50 to 60 per cent) is produced by the action of an electric current using platinum electrodes.

Complete de-emulsification results from using iron electrodes.

The essential part of the process is the removal of the oil by the basic ferrous carbonate precipitated at the anode coming into contact with the oil particles as they migrate to the anode; mechanical agitation of the emulsion with this precipitate serves, however, equally well to remove the oil.

A microscopic and photomicrographic study of the phenomena shows the oil to be held in the meshes of precipitate.

Colloidal ferric hydrate, a positive colloid, if present in sufficient concentration, effects complete de-emulsification.

Sodium carbonate coagulates colloidal ferric hydrate at a concentration less than that necessary to de-emulsify the oil and hence if colloidal ferric hydrate be formed during the process of electrolysis, it will be coagulated by the carbonate present before it can become effective as de-emulsifying agent. Therefore, colloidal ferric hydrate plays no essential role in the process. It seems that the chief agent in de-emulsification is the freshly formed basic ferrous carbonate resulting from electrolysis. The migration of the oil to the anode assists, however, in a measure, in the association of the two substances. The subsequent oxidization to ferric salts is unessential to the process, although precipitated ferric hydrate was shown to act as a good filter.

The efficiency of a number of precipitates used as filters for separating oil was investigated. Ferric hydrate and red ochre were found to be among the best.

From a photomicrographic study of coagula produced by precipitating emulsifiers and non-emulsifiers in oil emulsions, it appears that in general these substances, such as basic ferrous sulphate, lime, and alumina, which act as emulsifiers, may also serve to de-emulsify a mixture. Precipitation of the positively charged particles takes place on the negatively charged oil globules as nuclei in a manner analogous perhaps to the pre-

cipitation of water vapor on negative electrons. With non-emulsifiers, such as barium sulphate and lead chloride, the precipitation does not occur on the globules, but entirely distinct from them.

#### University of Pittsburgh.

A courteous speech of welcome was then made by Dr. McCORMICK, who, as the chancellor of the University of Pittsburgh, welcomed the society to the university. They have now a new and fine home in a growing district, where they can build up a big university.

Dr. McCormick spoke of man's kingship over nature. The Greek with all their fine brains did nothing to learn nature and natural forces and to harness them. This was left to the modern scientist and engineer. "Next to the minister of the gospel is the scientist." Not only does he add to the convenience and wealth of mankind, but he betters the place of man as man among the forces of nature.

Dr. McCormick indicated briefly the large plans which they have for the development of the University of Pittsburgh.

#### Tin Reduction.

A brief paper by Mr. W. O. SNELLING dealt with "an electrolytic method for the reduction of cassiterite." The author thought the present methods of reduction of tin from the ores are complicated and expensive. The method suggested by him is based on an observation made in a laboratory experiment in which he had cassiterite in contact with zinc in hydrochloric acid. The cassiterite was directly reduced to metallic tin by cathodic reduction. This system represented a short-circuited galvanic cell with zinc as anode and cassiterite as cathode. When the zinc and cassiterite are in contact, a current passes through the hydrochloric acid solution from the zinc to the cassiterite. Zinc goes into solution and cassiterite is reduced to tin.

On this observation a double-compartment cell is based which was tried by the author on an experimental scale. The cassiterite is cathode in the first compartment and anode in the second compartment. When a current is passed through the first compartment to the cassiterite as cathode, the cassiterite is reduced to metallic tin. Then by the throw of a double-pole switch, the current in the first compartment is stopped and current is passed through the second compartment. In this the action is simple plating; the tin passes into solution and is deposited as tin on the cathode in the second compartment. It is practically 99 per cent pure.

#### Cuprous Chloride Solutions and Copper Refining.

A paper by Dr. M. DEKAY THOMPSON and Mr. E. R. HAMILTON, of the Massachusetts Institute of Technology, dealt with the conductivity and electrolysis of cuprous chloride solution.

The only advantage that could be expected in refining copper from a cuprous chloride solution is that 96,600 coulombs of electricity would deposit 63.6 grams of copper, assuming 100 per cent efficiency, in place of half this quantity, which is obtained in the acid copper sulphate solution universally employed in copper refining. If the resistance of the cuprous solution were the same as the sulphate solution, and if the former worked otherwise satisfactorily, it is evident that the power now consumed for refining copper could be cut in half.

In order to show that cuprous chloride could be used in place of the sulphate solution, it is first necessary that the conductivity of cuprous chloride solutions should be equally satisfactory.

This salt is only slightly soluble in water, but dissolves in a solution of another chloride. Sodium chloride was the salt used for dissolving the cuprous chloride. Table I shows the solubility of cuprous chloride in sodium chloride.

TABLE I.

Concentration of Sodium Chloride.	Quantity of $\text{Cu}_2\text{Cl}_2$ Dissolved.		
	At 90°.	At 40°.	
Saturated solution .....	16.9 per cent	11.9 per cent	8.9 per cent at 11°
15 per cent solution ...	10.3	6.0	3.6 " at 14°
5 per cent solution ....	2.6	1.1	"

<sup>1</sup> Coehn, A. Über ein Gesetz der Electricitätserregung. *Ann. d. Phys.* (3) 64, 217-232, 1898.

<sup>2</sup> Noyes, A. A. Preparation and Properties of Colloidal Mixtures. *Jour. Amer. Chem. Soc.*, 27, 85, 1905.

The conductivity was measured of saturated solutions of cuprous chloride in solutions containing 15, 25 and 30 grams of NaCl in 100 grams water. The conductivities in table 2 are given in reciprocal ohms per centimeter cube.

TABLE 2.  
Saturated Solutions of Cuprous Chloride in Solutions of

Temperature.	I 15 Grams NaCl in 100 Grams Water.	II 25 Grams NaCl in 100 Grams Water.	III 30 Grams NaCl in 100 Grams Water.
25°	0.145	0.193	0.200
40°	0.188	0.245	0.258
50°	0.217	0.281	0.298

As compared with the conductivity of pure sodium chloride, the saturation with cuprous chloride lowers the conductivity of the solution. For example, the conductivity at 25° of a solution made by dissolving 25 grams of sodium chloride in 100 grams of water is 0.225 reciprocal ohms, while after saturating it with cuprous chloride it falls to 0.145. This can be counteracted by the addition of a small amount of hydrochloric acid, which at the same time clears up the turbidity. The measurements of table 3 were made of the conductivity of a solution made by dissolving 25 grams of sodium chloride in 100 grams of water, saturating with cuprous chloride and adding the indicated amount of hydrochloric acid of specific gravity 1.188 at 21.7°.

Cubic Centimeters of HCl added to 100 c.c. of Solution.	Conductivity.
1.115	0.195
1.595	0.204
2.08	0.206
2.52	0.215
3.26	0.224
3.66	0.230
4.32	0.237
4.81	0.242
5.55	0.251

For the sake of comparison measurements were also made on the conductivity of acid copper sulphate solutions. In electrolytic copper refining the solutions used in practice generally contain between 12 and 20 per cent of crystallized copper sulphate, and between 4 and 10 per cent free sulphuric acid, and are employed between 50° C. and 60° C. Measurements were made of two solutions: "A," containing 3.75 per cent free acid and 12.5 per cent copper sulphate; "B," 9.3 per cent free acid and 18.3 per cent copper sulphate. The specific gravity of A at 22.2° was 1.077; that of B at 21.2° was 1.199. The results of the conductivity measurements are given in table 4.

TABLE 4.		
Conductivity of Acid Copper Sulphate Solutions.		
Temperature.	Solution A.	Solution B.
25° C.....	0.1573	0.3260
40° C.....	0.1752	0.3754
60° C.....	0.1895	0.4252

As it thus appears that the conductivity of the cuprous chloride solutions can be made by the addition of free hydrochloric acid as satisfactory as that of copper sulphate solutions, the next point to be investigated was the amp-hour efficiency attainable in the electrolysis of cuprous chloride solutions.

Before studying the effect of impurities a few electrolyses were carried out in a pure solution, such as was used in the conductivity determinations. Two small cells containing a solution of 25 grams of sodium chloride in 100 grams of water saturated with cuprous chloride, and copper electrodes, were connected in series with a copper coulometer. The cuprous chloride cells were covered with a layer of liquid paraffine. In one cell the solution had turned to a deep brown, while in the second it remained nearly white.

On electrolyzing with a current density of 2 amp per square decimeter at room temperature the efficiency in the dark-colored cell was 78.2 per cent, and in the other 95.9 per cent, 100 per cent being twice taken as twice the amount of copper deposited in the coulometer. The anodes were eaten away badly at the surface of the liquid. This always took place in neutral solutions where there was no stirring. There was also a corresponding heavier deposit on the upper part of the cathode, as though the liquid conducted better at the top than at the bottom of the cell.

There was a great tendency to form crystalline trees of copper, so that where the current density was not uniform the tree would grow to the anode and short-circuit the cell. Stirring the solution prevented uneven solution of the anode and produced an even deposit on the cathode of a darker color than obtained with a sulphate solution. During the electrolysis the solutions tended to oxidize and form a green scum on the surface. The scum and the turbidity of the solutions can be removed by the addition of a little hydrochloric acid.

In order to see what effect the acid has on the electrolysis, to one portion of a solution of 25 grams of sodium chloride in 100 grams of water saturated with cuprous chloride just enough hydrochloric acid was added to clear the turbidity; to a second portion hydrochloric acid of specific gravity 1.188 was added in the proportion by volume of 4.6 of acid to 100 of solution. These were placed in cells with copper electrodes, and were connected in series with a coulometer and electrolyzed with current density of 0.75 amp per square decimeter. The cuprous chloride solutions were stirred by passing in hydrogen.

The results are given in table 5.

	TABLE 5. Electrolysis of Acid Cuprous Chloride Solutions.		
	Cuprous Chloride.		Copper Sulphate.
	No. 1.	No. 2.	
Voltage at start.....	2.0	0.18	0.36
Voltage after 2 hours.....	3.0	0.50	0.46
Voltage after 3 hours.....	0.84	0.20	0.35
Gain in weight.....	2.68 grams	3.05 grams	1.66 grams
Current efficiency .....	80.6 per cent	91.6 per cent	100 per cent

The deposits in cells 1 and 2 were both smooth and adhered firmly. After the electrolysis the solutions stood in contact with the anodes for 48 hours. After 24 hours the first solution had a bright green scum on the surface, and had become turbid, while at the end of 48 hours the second solution had only become a little darker in color. The copper was badly corroded at the surface of the liquid in Cell Number 1, while in Cell Number 2 it was scarcely corroded at all.

The general results of the investigations are summed up as follows: The conductivity of cuprous chloride solution can be made as high as that of the solutions ordinarily used in copper refining, by the addition of hydrochloric acid. At room temperature a current efficiency of 90 per cent of the theoretical can be obtained when the solutions are acidified. The presence of free acid is therefore beneficial in every respect.

#### Electrolytic Reduction of Nitric Acid.

A third paper "on the electrolytic reduction of nitric acid" was presented by Dr. HARRISON E. PATTEN and Mr. W. J. McCaughey, of the U. S. Department of Agriculture.

The results of their research are summed up as follows:

It is shown again that hydroxylamine may be reduced to ammonia at a copper cathode in presence of copper sulphate, sulphuric acid and hydrochloric acid. Nitrogen is liberated at both anode and cathode.

The rate of this liberation was studied quantitatively. Nitrogen is evolved at the anode at a fairly constant rate, ammonia being left in solution; at the cathode, nitrogen is set free rapidly at first, and in such quantity as to suggest the possibility of the formation of hydrazine as an intermediate step, and its subsequent oxidation by hydroxylamine, thus producing free nitrogen. As electrolysis proceeds, this formation of nitrogen gas decreases.

This initial evolution of free nitrogen in quantity is also met in the electrolytic reduction of nitrate under the same conditions, and suggests that the hydroxylamine formed in the reduction of nitrate may in that case, too, be reduced to a lower state of oxidation, such as hydrazine.

#### Conductivity of Soils and Corrosion of Steel.

"The Effect of Moisture and of Solutions on the Electric Conductivity of Soils" was the subject of a paper by Dr. R. O. E. DAVIS, of the Department of Agriculture. This is of importance in connection with the problem of the corrosion of



iron and steel pipes in soil. For if corrosion is an electrochemical phenomenon, the soil furnishes the electrolyte.

From previous work it is known that the condition of the soil has a marked influence on corrosion, and from a study of the soil conditions it has been observed that soil containing much water adds to the corrosive influence. Again, since corrosion is electrolytic, the solution in the soil facilitates corrosive action.

The measurements of soil resistivity show:

1. That in the dry condition, the soil offers a very high resistance to the passage of the current.
2. That at a depth of 2 ft. or more for a given soil and area, the conductivity remains roughly constant.
3. That the conductivity of moist soil increases almost directly as the percentage of moisture increases, the amount of increase depending upon the type of soil.
4. That the conductivity of soils saturated with water increases directly as the amount of salt in solution increases.
5. That below saturation, the resistivity increases almost in proportion to the surface area of the soil; at saturation and beyond, the surface area does not exert so great an influence.
6. That sodium carbonate has an effect of greatly increasing the conductivity.
7. That humus decreases the conductivity of a soil.
8. Sandy soil will probably afford least electrolyte and clay soil most, due mostly to the state of physical division of the soil.

From the data given in the paper it would be possible to calculate roughly the current produced by a given potential difference between two points in the soil, the cross-section of the soil column involved being known. In such a calculation the texture, content of organic matter, water content and saturation point of the soil must be approximately known, as well as the content of soluble salts present in the soil solution. Such calculations, while rough, would be of practical value.

#### Aluminium-Calcium Alloys.

A paper by Mr. JAMES M. BRECKENRIDGE, of the University of Wisconsin, dealt with "electrochemical potentials and electrical conductivity of aluminium-calcium alloys." It is an interesting example of metallographic methods in physico-chemical and metallurgical research.

Modern research has shown that combinations of metal may take the form of simple mixtures, solid solutions, or chemical compounds. In the two former, the physical and chemical properties of the alloy formed must result from a blending of the characteristic of the original metals. With the compounds, on the other hand, the union of these metals in atomic proportions may result in a substance with properties entirely at variance with those of the original constituents.

Since the alloys of the calcium-aluminium series present physical and chemical properties which were different from the original metals it was thought that this marked change of properties might be due to the presence of one or more chemical compounds, and for this reason a study of the constitution of the alloys of this series was undertaken.

The electrochemical potentials of the aluminium-calcium alloys were measured in a solution of calcium chloride in ethyl alcohol, since aqueous solutions would have reacted on the alloy directly. The potentials were measured against the standard calomel electrode, and a special connection was worked out between the ethyl alcohol solution and the calomel electrode. The electric conductivity of the alloys was simultaneously determined.

The curves of potential and of conductivity when plotted as functions of the calcium content of the alloy are quite smooth and regular with the exception of a distinct break in both curves between 32 and 34 per cent calcium.

The single potential rises suddenly from 0.4810 to 32.8 per cent Ca to 0.9120 at 34.3 Ca, while the electric conductivity curve which was falling all the time with increasing calcium

content reaches between 32 and 34 per cent Ca a minimum, rises again slightly to a maximum, and then continues to fall. In the latter curve the break is less evident than in the potential curve.

The composition of the alloy, where the break in the two curves occurs, corresponds to the formula  $Al_2Ca$ . This is further in agreement with the results obtained by Donski (*Zeit. f. anorgan. Chemie*, Vol. 57, p. 201) in the study of the cooling curves for this particular series.

#### Rotating Graphite Anode.

A paper by Dr. J. W. TURRENTINE, of Wesleyan University, describes a rotating graphite anode designed to accompany his graphite cathode dish. The author hopes that the graphite anode may be found capable of supplanting the more expensive platinum anode in electrochemical analysis and other electrochemical processes where the rotating anode is used. The anode is placed above the graphite cathode dish; this offers certain advantages.

The anode used was fashioned from a platinum dish by cutting 10 radial slits in its sides and by soldering, or otherwise fastening, across its top a stout platinum wire, to the center of which was attached, T-wise, a perpendicular platinum rod to serve as the axis of rotation.

The graphite anode is constructed of an especially hard grade of Acheson graphite. It is dish-shaped. It is cut from stick graphite, and is turned down on a lathe to the desired size and thickness. To overcome the porosity of the graphite it is treated with paraffine or ceresine.

#### Rapid Electro-Analysis.

A first paper, by Prof. FRANCIS C. FRARY and Mr. ANDREW P. PETERSON, of the University of Minnesota, on a "comparison of rapid electro-analytical methods," dealt with the determination of copper. Rapid electro-analytical methods depend on some process of stirring the electrolyte and bringing continually free electrolyte to the cathode; they differ by the special method of stirring employed.

The following three methods were compared: Magnetic rotation of the electrolyte with a gauze cathode (Frary); rotating spiral anode and dish cathode (Smith); simple use of platinum-gauze cathode without rotation (Stoddard), depending on evolved gases and convection currents for the necessary agitation. They used as electrolyte a copper sulphate solution with addition of as small a quantity of nitric gas as possible.

From their determinations, more than 150 in all, the authors conclude that, "in the case of copper, precipitation by the rotating anode is complete and satisfactory in a few minutes less than with magnetic rotation. Precipitation with magnetic rotation is complete and satisfactory in a little shorter time than when no rotation is used. In the last case, however, the character of the precipitate is much more variable, and often for no apparent reason the deposit becomes unweighable. Possibly with the use of somewhat more nitric acid the character of this deposit might have been improved, but the time required would naturally have been longer and the certainty of complete precipitation much less. In all cases the solution should be heated to 70° before electrolysis, the heat evolved by the current maintaining this temperature during the process.

"It is to be noted, however, that the comparatively favorable results obtained in the deposition of copper on the gauze cathode alone do not show that stirring or rotation of the solution may be generally dispensed with. Copper is well known to be one of the easiest metals to deposit under widely varying conditions, and it remains to be seen what results can be obtained with other metals."

#### Electrodeposition of Platinum.

A paper by Mr. W. J. McCaughey and Dr. HARRISON E. PATTEN, of the U. S. Department of Agriculture, gives a report of their continued researches on the electrodeposition of plati-

num and on the conditions under which the different forms of cathodic platinum deposits are obtained.

They employed aqueous solutions of potassium chlorplatinat and of ammonium chlorplatinat without or with citric acid. The conditions of producing the different forms of platinum deposit were studied and in addition anode and cathode discharge potentials were taken to assist in the interpretation of the differences observed in the deposits of platinum and the result of citric acid.

The results are given in detail in numerous tables.

#### Lead Plating and Refining.

A paper by Prof. FRANK C. MATHERS, of the University of Indiana, describes experiments with the lead perchlorate ( $\text{Pb}[\text{ClO}_4]_2 \cdot 3\text{H}_2\text{O}$ ) plating and refining bath. The properties of lead perchlorate, which are of special value in a plating or refining solution, are: Great solubility; smoothness and denseness of cathode deposits and freedom from "trees"; approximately theoretical corrosion of the anode and deposition upon the cathode; absolute stability under all conditions to which it is subjected in a plating or refining bath; no polarization from the formation of lead peroxide on the anode; and very high electrical conductivity.

Sodium perchlorate was used as the starting material for the preparation of the perchloric acid. The solid dry sodium perchlorate was treated with an excess of concentrated hydrochloric acid. After thorough stirring to break up lumps, the mixture was filtered through asbestos and the residue of sodium chloride was washed with successive small portions of concentrated hydrochloric acid. The filtrate, consisting of a mixture of aqueous perchloric acid, hydrochloric acid, and small amounts of sodium perchlorate, was heated on the hot plate until the temperature reached  $135^\circ$ . This completely volatilized the hydrochloric acid with only an insignificant loss of perchloric acid. This aqueous perchloric acid is stable, and is no more dangerous to handle than nitric acid. The lead perchlorate was made by neutralizing this aqueous perchloric acid with litharge.

The electroplating or refining bath should contain about 5 per cent of lead, 2 to 5 per cent of perchloric acid, and 0.05 per cent of peptone. The latter was found the most suitable "addition substance." (Without any addition substance the lead perchlorate bath does not give good lead deposits, except at very low current densities.) A current density of from 2 amp to 3 amp per square decimeter (18 amp to 27 amp per square foot) may be used. The peptone is gradually used up, and after about four days a quantity equal to the original amount should be added. The free acid, which is very slowly neutralized by chemical solution of the lead, must be restored by the treatment of a suitable portion of the solution with the right amount of sulphuric acid. This precipitates lead sulphate and leaves perchloric acid in solution. The filtrate is to be returned to the bath.

The bath gives excellent purification, the cathode being about 99.98 per cent pure. The deposit is smooth, coherent, and has a density of 11.36. As a plating bath, the lead perchlorate solution works exceptionally well on account of the absence of "trees" or loose crystals on the edges even when the deposits reach a thickness of an inch. The bath shows no deterioration with use, and gives as good deposits after two months as at the beginning, if the concentration, acidity, and the required amount of peptone are maintained.

The author sees no reason why the perchlorate bath cannot be applied on a commercial scale, especially for plating of lead, since the deposits are of exceptional smoothness and entirely free from trees or loose crystals on the edges or points.

In opening the discussion Dr. Baekeland said that the use of peptone as a nourishment of an electrolytic bath was a novel idea. Dr. Richards referred to the paper as a striking example of successful research on the use of addition agents. In this field we have not yet reached finality. Without giving further

details he referred to a plating process in which the addition of a small amount of a new organic substance not only gives a better deposit, but permits to increase the current density to thus reduce the time.

#### New Mercury Cell for Alkali Chloride Electrolysis.

A paper by Mr. JASPER WHITING, of Boston, Mass., described his new cell for the production of caustic alkali and chlorine by electrolysis of alkali chlorides. The Whiting cell is a mercury cathode cell.

The author thinks that the mercury type of cell, from the purely theoretical standpoint, is the best thus far conceived, chiefly because it is free from diaphragm troubles and produces in one operation pure caustic alkali. When one considers, however, that the first mercury cell was invented more than 20 years ago, that the patent office is full of patents covering cells of this kind, and that there has been up to the present time only one successful process, the Castner, in commercial operation in this country, it is easy to believe that while the idea is simple, there must be innumerable difficulties in the way of the successful operation of mercury cells.

Moreover, while certain mercury cells seem to work well on a small scale, the results are difficult to duplicate in a plant of commercial size. The cells of Rhodin, Bell, and Baker, are mentioned as examples. Moreover, a well-seasoned apparatus in the hands of men inexperienced in the idiosyncrasies of mercury and sodium amalgam has never been a success. This is instanced by the fact that the Japanese, though possessed of all the published knowledge of the Castner Company, and with all the rights to use the Castner patents, lost \$100,000 before the unsuccessful attempt to make bleach and caustic soda by the Castner process in Japan was abandoned. On the other hand, the Castner process is one of the most striking successes of the whole electrochemical field. The company has a very large plant at Niagara Falls and other plants in Europe, and has been paying dividends on its capital for very many years. The fact is that sodium amalgam is a most elusive and contrary material. In the language of a man well qualified to judge, it defies all the laws of nature.

The chief stumbling block in the way of the successful operation of mercury cells is the difficulty of removing the sodium amalgam in a uniform and continuous manner from the decomposing chamber where it is formed to the oxidizing chamber. If this amalgam is not so removed, it tends to accumulate in the decomposing chamber until, when a certain concentration is attained, violent secondary reactions are set up with consequent lowering of the efficiency of the cell. In the ordinary type of apparatus the mercury is caused to flow in a wide and shallow channel from one compartment to another. Hydraulic engineers have long recognized the fact that when a stream of water flows through such a channel the liquid travels much more rapidly in the center than on the sides because the friction of the walls of the channel holds back the material adjacent thereto. If this is a serious difficulty with such a simple fluid as water it is doubly so with a complex fluid such as mercury, and its overlying strata of sodium amalgam. As a result, the sodium amalgam tends to accumulate to an excessive degree with consequent lowering of the current efficiency.

In the Whiting cell a principle, new to this type of apparatus, is employed for the purpose of overcoming the above difficulty. This cell operates intermittently. A body of mercury is placed in the decomposing compartment and held there in a stationary position, as regards the anodes, for a given length of time, during which sodium amalgam of the desired concentration is produced. This amalgam is then completely drawn off from the decomposing compartment, and when removed its place is taken by another body of mercury free from sodium. By placing a number of these compartments in parallel, and operating them successively, the cell, while intermittent in principle, is continuous in its action.

The Whiting cell is a massive concrete structure, supported



on four concrete pedestals, but insulated therefrom. It consists of a shallow receptacle, or box, divided into two compartments, "A" and "B," by a concrete partition. The bottom of the larger or decomposing compartment, "A," is divided by low glass partitions, "C," into a number of sections. The sections have V-shaped bottoms sloping at a slight angle toward central slots "D," these slots being carried through the dividing concrete partitions into the smaller, or oxidizing compartment, "B," where they turn upward and are closed by poppet valves "E," operated by cams, "F," attached to a slowly revolving shaft, "G."

The other ends of these slots are connected one with another by means of a common channel, "H," called the distributing level, and this channel connects in turn with a secondary channel, or run, "I," which leads through one of the side walls of the cell to a pump, "J," at the extreme end of the oxidizing compartment. Mercury covers the bottom of the decomposing compart-

ment. The current, supplied to the anodes from the busbars, flows through the brine solution to the mercury and out through the bottom of the cell through iron rods, "R," partly embedded in the concrete and serving to connect the mercury in the cell with the cathode busbar.

The current passing through the electrolyte decomposes the brine, chlorine is given off at the anodes, escaping upward, and sodium is separated at the surface of the mercury, amalgamating therewith. When this action has proceeded for a predetermined period of time, approximately two minutes, the poppet valve at the point of exit of one of the sections is opened by the action of the cam, and the entire mass of sodium amalgam contained in that section sinks rapidly into the slot and down through the connecting pipe into the oxidizing chamber.

The period required for the emptying of a section having been accurately determined, the design of the cam is such that when the mercury is all out of the section the valve closes.

Mercury free from sodium then flows into the empty section by way of the distributing level, and continues to so flow until the common level is established. In the meantime, the sodium amalgam in the oxidizing compartment flows by gravity successively over the graphite plates and in so doing it is freed from the sodium it contained, only pure mercury reaching the pump pit, this pure mercury being raised then by the rotary pump into the wall pipe of the decomposing department, through which it flows by gravity to the distributing level. Thus is the cycle completed.

By operating the sections successively, the action of the cell is, in effect, continuous, though the action of each individual section is intermittent.

It is easy to see the advantages of the electrical conditions in the decomposing compartment. A body of mercury is placed in a stationary position as regards the anodes, and at such a distance from them as is theoretically the best; therefore, the distribution of the current is uniform and the resistance of the electrolyte a minimum.

Moreover, as there is no agitation of the mercury, during the period of electrolysis, secondary reactions are not facilitated, and as the initial primary conditions are re-established at frequent intervals, uniformity of operation is maintained.

In order to operate the cell satisfactorily it is necessary to feed brine of great strength uniformly between the electrodes. As the electrodes are very close together, and as the area of the cell is considerable, this appeared at first to be a serious difficulty. The problem was solved by utilizing the intermittent action of the mercury in the sections to control the operation of a device for feeding the brine.

Cup-shaped receptacles, "S," equal in number to the sections of the decomposing chamber, are formed in the cover, "N," of the decomposing compartment, these receptacles being connected by a common channel, "T," at their upper extremities. Through the bottom of these cups glass tubes "U" extend downward between the anodes and end of each tube terminating below the surface of the mercury, at a point near the middle of each section.

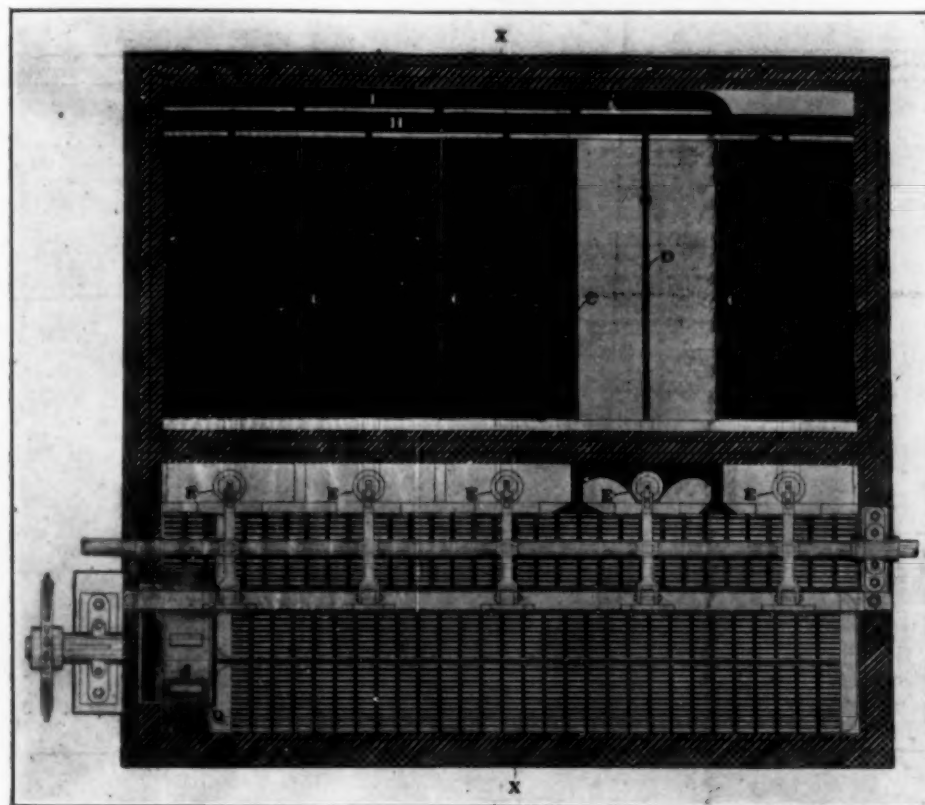


FIG. 1.—WHITING ELECTROLYTIC CELL PLAN.

ment, filling to a common level the several sections above described.

The anodes, "K," consisting of slabs of Acheson graphite, perforated to permit the free discharge of chlorine, rest upon ledges, "L," placed at the ends of the sections in such a way that the distance between the electrodes shall be a minimum. To these anodes are fastened graphite leads, "M," which extend upward through the cover, "N," connecting with the busbar.

The oxidizing chamber is divided into three channels, "P," lined with graphite of special design, and sloping successively downward to form a zigzag path to the pump pit "Q," where a stoneware rotary pump, "J," also of special design, is placed and operated by auxiliary means. A common body of electrolyte, brine, fills the decomposing chamber, and water or caustic the oxidizing compartment.

The action of the cell is as follows: The floor of the several sections of the decomposing chamber is covered with mercury, which is maintained at a common level by means of the dis-

Brine is fed into one of these cups from an outside source and when the cup is full the brine overflows into the channel, filling each of the cups in turn. As long as the sections are filled with mercury, the bottoms of the tubes are sealed, so that no brine can flow into the cell, but as soon as the mercury is withdrawn from one of the sections the seal is broken on the corresponding tube and a definite quantity of concentrated brine corresponding to the size of the cup flows into that individual section.

As this brine has a greater specific gravity than the partly electrolyzed brine in the cell, it sinks to the bottom and spreads laterally, forming a layer of about 1/16 in. thick over the glass plates. When the purified mercury again fills the section, the new brine, free from chlorine, acts as a protective layer to it, and is in its proper position for being electrolyzed. Moreover, as the brine enters the cell at a time when the section is empty, it causes no agitation of the mercury, and consequently facilitates no secondary reactions.

The action of the oxidizing chamber of the cell could hardly be more simple, and it has the distinct advantage of being automatic. The graphite slabs are so designed as to form a large number of channels through which the mercury flows. The sides of these channels extend upward into the caustic solution, and form with the amalgam a galvanic couple, which serves to decompose the amalgam.

The principle of this action is by no means new, but Mr. Whiting thinks that it has never been successfully employed in an electrolytic cell until now. The difficulty lay in maintaining a proper contact between the amalgam and the graphite. It is easy to secure contact at first, but after the action has proceeded for a varying length of time, the graphite tends to become polarized by the hydrogen given off at its surface, until the necessary contact between it and the amalgam is destroyed.

Mr. Whiting has overcome this trouble by means of a very simple device. Holes about 1/8 in. in diameter and 1/2 in. deep are bored at frequent intervals in the graphite slabs, and these holes are filled with pure mercury before starting to operate the cell. This pure mercury makes, of course, an effective contact with the graphite walls, of the holes, especially as it is under a relatively high head, and, as it is also in contact with the sodium amalgam which flows above it, it forms a connecting link between the sodium amalgam and the graphite.

Moreover, as sodium amalgam is lighter than mercury, and as the holes are narrow and deep, there is little tendency for the sodium to diffuse downward; consequently the mercury in the holes remains pure, and, as there is no action between it and the graphite, there is no serious polarization of the walls of the holes, and, as a result, the original contact between the mercury and the graphite is not destroyed.

In practice, this galvanic action proceeds at a very vigorous and uniform rate until all the sodium in the amalgam is oxidized, when it automatically stops, pure mercury being delivered to the rotary pump to be returned to the decomposing chamber.

This method of oxidizing amalgam is thought to be superior

to that employed in any other cell operating on a commercial scale. It requires no attention, being at all times automatic and is free from mercury losses. Caustic of almost any desired concentration may be produced. It is only necessary to regulate the amount of water fed into the chamber to produce the strength desired. The caustic formed is, as already stated, practically pure.

One of the features of the Whiting cell is its accessibility. This is largely by reason of the construction of the cover of the decomposing compartment. This cover is made of reinforced

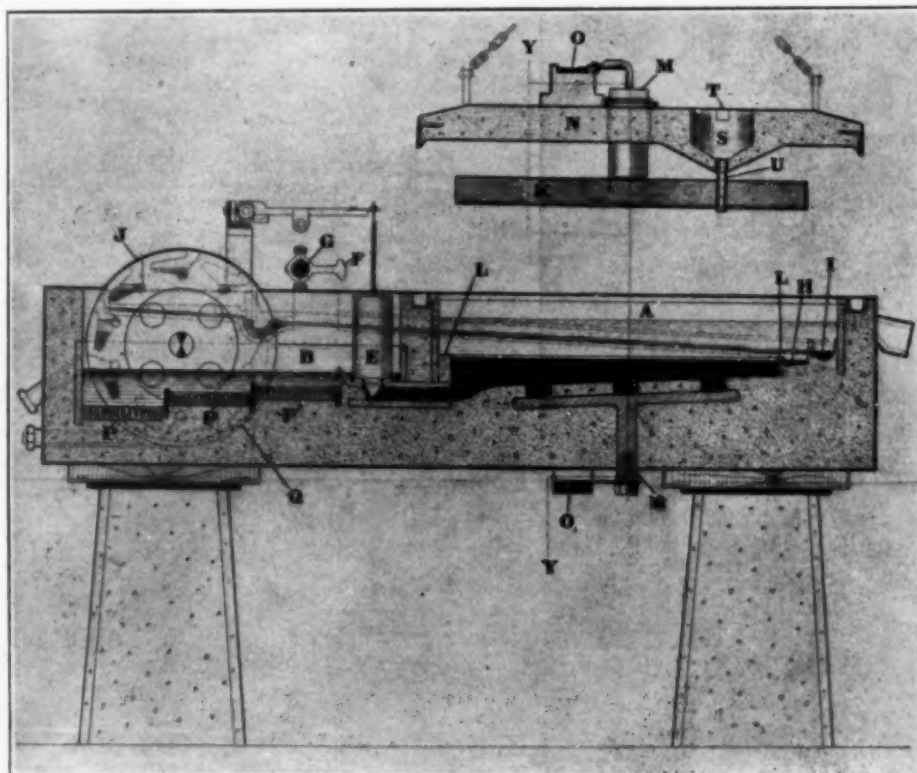


FIG. 2.—WHITING ELECTROLYTIC CELL. CROSS-SECTION.

concrete, with edges extending downward to loosely fit into channels made in the top of the wall of the decomposing compartment, thus forming a gas-tight, liquid seal. The anode leads extend upward through the cover and, while removable, are so arranged that when the cover is raised, the anodes are raised also. To the cover, likewise, are fastened the busbar and the system for feeding the brine, consequently, when the cover is lifted, all the auxiliary apparatus in connection with the decomposing chamber of the cell is removed in one operation, permitting a rapid inspection and cleaning of the cell.

There is, of course, no fixed limit to the size of the Whiting cell. As each section works independently, one from another, the sections may be multiplied in number as desired, until a cell of capacity suited to the conditions is produced. The cell which has been developed at the plant of the Oxford Paper Company, at Rumford, Maine, is about 6 ft. square over all. It contains five sections, and is operated with a current of from 1200 amp to 1400 amp, equivalent to a current density of over 100 amp per square foot of active anode surface. The voltage across the terminals is approximately 4, and the cells operate at a current efficiency of from 90 per cent to 95 per cent.

Mr. Whiting thinks his cell is the only one which can be shut down without noticeably affecting its efficiency or without injury to the apparatus. To illustrate this in a practical way, during a test run of four cells the current was shut off for various reasons 11 different times for periods varying from a few minutes to 12 hours, but in spite of these many shut-downs the plant maintained an average current efficiency of over 95 per cent.



In case of shut-down it is only necessary to stop the operation of the pump, when all the mercury is automatically drawn off from the decomposing to the oxidizing compartment, where it remains until it is again desired to start the cell, which is accomplished by the starting of the pump. As the mercury is all out of the decomposing compartment while the current is off, there is no loss of mercury due to the corrosive action of the

maintaining 2 per cent being hydrogen, and as the chlorine leaves the cell at a relatively low temperature, it is unnecessary to cool it further before using it to form bleaching liquor.

The Whiting electrolytic cell is not an expensive cell to install. It is generally believed that mercury cells are very costly, for the reason that large quantities of mercury are required in their operation, and mercury is, of course, a high-priced material.

When one considers, however, that the use of mercury eliminates the necessity of installing very expensive and rapidly deteriorating multiple-effect evaporating machinery and auxiliary apparatus for the purification of the caustic produced in diaphragm cells, it is easy to see that one expense largely offsets the other. Moreover, mercury is a quick asset convertible into cash at a high proportion of its first cost.

The present plant, erected for the Oxford Paper Company, has a capacity in bleach-liquor equivalent to about 5 tons of bleaching powder per day, and produces, in addition, about 2 tons of pure caustic soda. This plant has been operating since early in January, and the results obtained from it have been so satisfactory that its capacity is

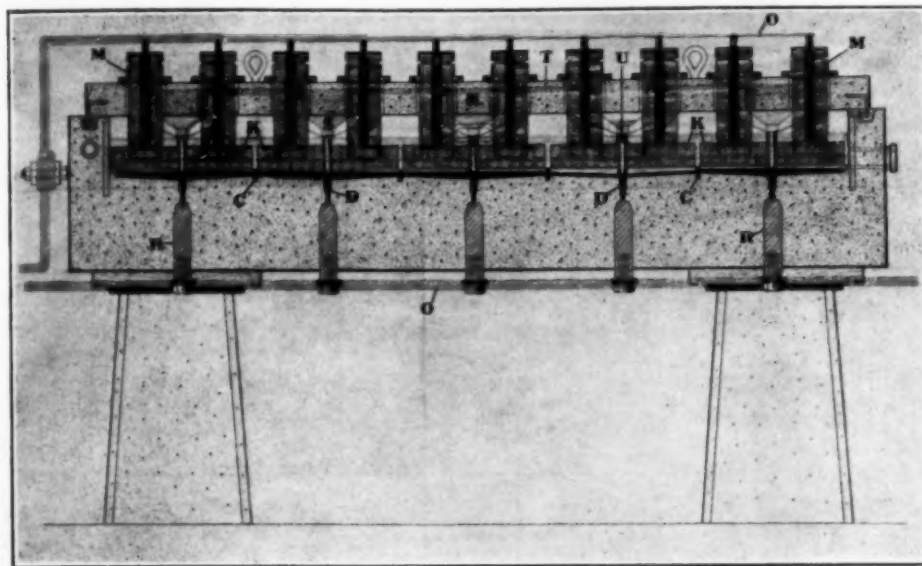


FIG. 3.—WHITING ELECTROLYTIC CELL. LONGITUDINAL SECTION.

chlorinated brine, as is the case with other types of mercury cells.

Moreover, the Whiting cell is singularly free from injury on account of accidents. Should there be an unexpected stoppage of the pump, the mercury leaves the decomposing chamber as above described. Should one of the valves leak, the level of the mercury in the decomposing chamber will be slightly affected, with a corresponding increase in voltage, but no serious damage will be done. Should one of the valves fail to operate sodium would accumulate in the mercury of that section, but the remainder of the cell would operate satisfactorily.

Occasionally the cell has to be washed, to free it from precipitated graphite dust and from slime which forms on the glass plates. The operation of washing a cell is, however, an extremely simple one and requires the labor of but one man for about half an hour.

As the cell is operated at a temperature below 40° C., the tendency to form chlorates is very small and, consequently, the deterioration of the graphite anodes is reduced to a minimum. There is, of course, no depreciation of the graphite slabs in the oxidizing chamber of the cell.

As before stated, the mercury type of cell produces pure caustic. Consequently the cell efficiency, as far as the caustic is concerned, is the plant efficiency. There are no losses incident to subsequent treatment. What flows out of the cell is the finished product, assuming, of course, that liquid caustic is sold. The chlorine gas escaping from the cell is 98 per cent pure, the re-

now being increased five times.

In the discussion which followed Prof. C. F. Burgess pointed out the great difference which exists between laboratory apparatus and commercial apparatus. In reply to several questions by Dr. Baekeland, Mr. Whiting stated that the loss of the mercury has been found to be less than 6 per cent per year, but the estimates of the cost had been based on an assumption of 10 per cent loss of mercury per year. The strength of the cathode liquid is usually 20 per cent, but caustic has also been made 40 per cent strong. There is no further concentration then neces-

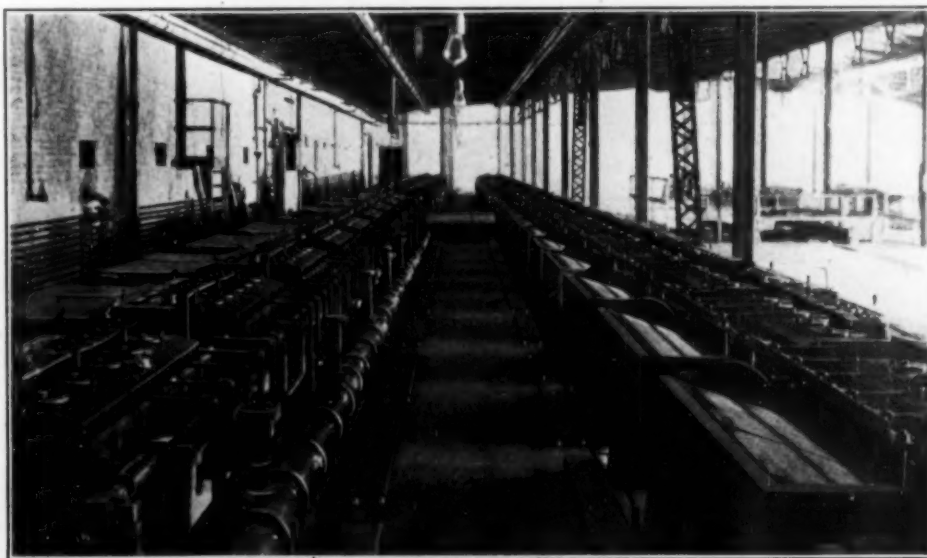


FIG. 4.—WHITING ELECTROLYTIC CELL. INSTALLATION OF OXFORD PAPER COMPANY.

sary. The cell is washed about once a month. In reply to a question of Dr. Richards as to possible evaporation of mercury and its effect on the workmen, Mr. Whiting said that the mercury could not evaporate, since it was always covered.



With respect to the formation of hypochlorites and chlorates in chloride electrolytic cells, Dr. Baekeland said that when the chlorates and hypochlorites begin to participate in the electrolytic action they are decomposed and oxygen is evolved or oxygen compounds, including sulphates, are formed at the anode. This causes a destruction of the anodes, even of graphite anodes, which are practically indestructible by chlorine, but are corroded in sulphate. This is not only a serious item of expense, but the internal resistance of the cell is increased and the whole operation is disturbed. Treatment of the anode with paraffine would help nothing, since paraffine absorbs chlorine. Cast-iron oxide anodes are used in Germany to a certain extent, but they also involve some disadvantages. Dr. Baekeland finally pointed out that the proper design of the contacts was a very important problem for an electrolytic cell.

#### Townsend Cell.

A paper by Messrs. H. K. RICHARDSON and R. L. PATTERSON, of Cornell University, gave an account of experiments made with an experimental Townsend cell. The object was to determine the effect of current density (varied from 18 amp to 500 amp per square foot) on efficiency and output. The watt-hour efficiency and amp-hour efficiency drop, of course, with increasing current density. The numerical results were given in a table. The authors also determined the effect of variation of the flow of anode liquor on the results.

In the discussion Mr. Hooker, of the Hooker Electrochemical Company, pointed out that the commercial Townsend cell, as operated by this company, is giving far more favorable results, the difference of the numerical results being due to the use of dimensions in the authors' experimental cell, quite different from those used in the commercial cell.

Dr. Baekeland remarked incidentally that running a Townsend cell at a high current density is advantageous on account of the scrubbing action of the hydrogen gas.

#### Electrolytic Winning and Refining of Metals.

A paper by Mr. EDWARD M. CHANCE, of Pottsville, Pa., describes "a new method for the electrolytic winning and refining of metals." He suggests a process of treating mattes and speisses by electrolysis in the fused state.

Robert H. Aiken has patented such a process (U. S. patent 873,648, Dec. 10, 1907). Mr. Aiken's method consists in fusing a sulphide ore containing nickel, copper, and iron, such as pyrrhotite, or the matte from such an ore, and directly electrolyzing the same. He claims that the copper and nickel may be readily separated as metals, from the fused sulphide, while the iron sulphide will remain undecomposed if the difference in potential between the poles be properly controlled. If, after the removal of copper and nickel, the voltage be increased, the iron will be deposited. In both cases sulphur is liberated at the anode.

Mr. Chance comments on this as follows: "It would seem that insuperable obstacles would lie in the way of the commercial application of such a process. First of all I believe that there would be considerable loss of electrical energy, as I understand that such a bath would conduct current directly, without the current doing electrolytic work. The separation of the metals would not be sharp. Mr. Aiken himself acknowledges that the copper-nickel deposit is largely contaminated with iron, which he suggests may be removed by subsequent refining. It seems reasonable, also, that metals so deposited would retain considerable sulphur."

Mr. Chance proposes a process in which a fused electrolyte is superimposed upon the fused matte. The most troublesome elements, arsenic, antimony, and sulphur, would volatilize at the temperature required, thus keeping the electrolyte clean, and ensuring uncontaminated deposits on the cathode.

The author made experiments on a small scale in a crucible filled with the fused matte, which was electrically connected to the outside circuit by means of an iron wire in the bottom of the crucible. This formed the anode. The electrolyte was

then added and a carbon or steel rod, forming the upper electrode (cathode) and dipping into the electrolyte, was inserted through a hole in the top. This cell was inserted in a gas furnace. Current was obtained from a battery of four cells.

Experiments were made with the electrolysis of copper-iron mattes of about the following composition: Copper, 50 per cent; iron, 24 per cent; sulphur, 26 per cent. The electrolyte found most efficacious was a sodium metasilicate. It was found that by controlling the difference in potential across the poles, a very pure copper could be deposited on the cathode, iron remaining in the electrolyte as silicate. When the e.m.f. was increased, both iron and copper were deposited apparently as alloy, on the cathode. The sulphur appeared to volatilize entirely at the anode, none remaining in the electrolyte or upon the cathode.

With a nickel-copper-iron matte or speiss, the copper could be deposited selectively, and when all the copper had been removed from the electrolyte, the nickel could be removed free from iron, by increasing the e.m.f. It is understood, of course, that the voltage must be kept below the point at which iron silicate is decomposed. In the case of speisses the arsenic and antimony appeared to volatilize quantitatively.

Attempts were made to use halogen salts in place of silicate in the treatment of mattes. It was found, however, that at the temperatures used, chlorides of the alkalis and alkaline earths were both volatile and unstable, while calcium fluoride was not sufficiently fluid.

Chloride of sodium, however, was found very useful in the electrolysis of alloys with low fusion points, such as silver-lead.

The author mentions that by this process a very sharp separation of silver from lead in a silver-lead bullion was made. This alloy was attacked with a sodium lead silicate electrolyte, the lead being carried over to the cathode, while the silver remained unattacked at the anode.

It is stated that the metals deposited on the cathode by these processes were marked by great adherence as well as purity. Copper when plated upon the 9 mm steel-rod cathode could be removed only by filing. It was possible to hammer, bend and otherwise deform the steel, without loosening the copper coating.

In the discussion Dr. Richards remarked that he had repeated in his laboratory Mr. Chance's experiments and found the method to work, but he was not sure whether the deposition of the copper was really electrolytic.

A motion of thanks to Pittsburgh for its splendid hospitality was then unanimously passed.

#### Public Meeting.

In the afternoon an open meeting was held in the Carnegie Music Hall, to which the general public had been invited. It was well attended. Mr. Charles F. Scott presided. He said that Pittsburgh's pride in the past had been tonnage, but times are changing, and Pittsburgh which has profited so much by science in the past will profit still more by science in the future, with respect to quality and efficiency as well as to tonnage.

#### Electrochemical Industries.

Dr. JOSEPH W. RICHARDS delivered an address on "the present status of the electrochemical industries." If all the electrochemical industries were put together on one spot, they would equal the industries of Pittsburgh. But they are scattered all over the world. At present there are only two electric steel refining furnaces in regular operation in the Pittsburgh district, but in other places of the world there are almost 100. But when Pittsburgh takes up a thing it is done with elementary energy. Dr. Richards predicted a great future for the electric steel furnace in Pittsburgh.

A concise sketch was then given of the various classes of electrochemical industries—electrolytic processes, electric furnace processes, and processes employing the electric arc and electric discharges in general. Dr. Richards then showed in a

long series of lantern slides typical installations of such processes, to carry home his main point, that electrochemical processes do not simply exist on paper, but that electrochemical industries are a reality, an accomplished fact of considerable commercial importance to-day. But the future is even brighter.

There is now a demand and a necessity for cheaper power, and the developments along this line change the commercial geography of the world.

#### Conservation of Natural Resources.

Mr. JOHN H. FINNEY, secretary of the Southern Appalachian Conservation Commission, then delivered an address on "the conservation and utilization of natural resources of power."

The conservation policy got its mighty impetus in the Governor's meeting called by Roosevelt to the White House; it was the first gathering of its kind in the world.

Conservation is a moral issue. The speaker paid a tribute to Mr. Pinchot. The result of the propaganda has been an aroused national conscience.

Mr. Finney then classified our resources as exhaustible and inexhaustible. Exhaustible are coal, natural gas, oil, peat, wood. Inexhaustible are manual labor, animal labor, wind power, sun power, water-power. All of these resources were discussed with reference to the waste now going on. With respect to coal, the speaker dealt especially on by-product coke ovens and the utilization of waste gases.

As to water-power the speaker said that not every water-power is a gold mine, yet the question of regulating the status of water-powers in this country is of immense industrial importance. The question of ownership and rights of water-power in this country is exceedingly complicated. We have individual ownership, State ownership and joint ownership. It is a complex and serious problem.

Complete individual independence is only possible where man is isolated. Otherwise regulation by the State becomes necessary. Development of a water-power is no longer to be considered as a private investment of an individual. Since electric power transmission has become a reality, a water-power is now a public utility.

Mr. Finney gave a review of water-power legislation in Europe, especially in Switzerland, Italy, and France. He outlined the fundamental principles of desirable legislation for this country and urged that the question should be fearlessly taken up, or what are still free and equal and open opportunities will be closed forever.

#### Concluding Speech.

The final speech of the meeting was made by Dr. JOHN A. BRASHEAR, the astronomer, who had been introduced by Mr. Scott as one of "Pittsburgh's civic assets."

Dr. Brashear gave in a delightful and humorous speech some of "the beautiful reminiscences of a lifetime," of his coming in contact in years past with many eminent scientists and engineers, and especially reminiscences of the early work of Dr. E. G. Acheson, who began his brilliant career on a small scale in Pittsburgh. "Don't believe he started to do it for the money that might be in it. He did it because it was in him. He had to do it."

The meeting was finally closed with a few felicitous words by the retiring president, Dr. L. H. Baekeland.

#### Social Functions and Excursions.

As stated before, the society was royally entertained. On Wednesday evening there was an informal reception in the English room of the Fort Pitt Hotel by the Pittsburgh local committee and the officers of the society to visiting members, guests and ladies. On Friday evening a subscription dinner was held at the Fort Pitt Hotel, Mr. C. F. Scott acting as toastmaster.

A special program had been arranged for the entertainment of ladies. Various excursions, among them one to the Heinz factory, were made on Thursday afternoon, while a theater

party had been arranged for the evening. On Friday a visit was paid to the Margaret Morrison School of the Carnegie Technical Schools, followed by lunch at the Hotel Schenley, an automobile trip through Pittsburgh's parks and boulevards in the afternoon, and the dinner in the evening.

The most delightful feature of the whole convention was, however, the eminently successful excursion program. This had been arranged with utmost care for the minutest details. Pittsburgh's hospitality could indeed not be better shown than by the wide-open doors of its industrial establishments, and the utmost efforts were made to keep every visitor fully informed on all the features of the plants visited, which were specially worth seeing.

In this respect the handbook prepared by the local committee and containing concise, illustrated descriptions of the engineering features of the various plants, was a novelty so successful that we would wish that similar handbooks might be prepared for all future meetings, if we did not know that this would be practically impossible. The preparation of the Pittsburgh handbook must have required an enormous amount of work and the highest credit is due to the editors. The book is, moreover, exceedingly well printed and neatly illustrated. One of the illustrations of the handbook is herewith reproduced, that is, the view of the crucible furnace of the Crucible Steel Company of America—the largest in the world. For the photograph from which the cut was made we are



A 60-POT CRUCIBLE FURNACE. THE LARGEST IN THE WORLD.  
CRUCIBLE STEEL COMPANY OF AMERICA.

obliged to Mr. P. Kemery, of the Crucible Steel Company of America.

The following gentlemen were in charge of the various excursions. Wednesday excursion: Messrs P. Kemery and W. O. Snelling. Thursday excursion: Mr. H. Rodman, general chairman; Mr. Bruce Warner, Isabella Furnaces; Mr. George S. Page, Crucible Steel Co.; Mr. H. H. Laughlin, Jones & Laughlin Steel Co.; Prof. F. Crabtree, Pennsylvania Smelting & Refining Co.; Mr. William Kinney, Universal Portland Cement Co.; Mr. H. K. Hitchcock, Brazing, and Mr. Max Harris, Nernst Lamp Co.

Friday excursion: Mr. P. Kemery, general chairman; Mr. G. S. Page, train arrangements; Mr. H. K. Hitchcock, at Allegheny Plate Glass Co.; Mr. H. Rodman, at Westinghouse Machine Co.; M. B. Wiley, at Westinghouse Electric & Mfg. Co.; Mr. E. B. Clark, at Firth-Stirling Steel Co.; Mr. L. T. Watson at Homestead Steel works.

#### U. S. Geological Survey Testing Station.

On Wednesday afternoon the Testing Station of the Technological Branch of the U. S. Geological Survey was visited. A number of very interesting and instructive tests had been specially arranged for this occasion.

Two tests were made to determine the effect of a charge of an explosion when fired into 120 pounds of bituminous



coal dust from the Pittsburgh seam, placed on horse and on side shelves, in a dust gallery. In another test the unit disruptive charge of blasting powder, tamped with two pounds of dry fire clay, was fired at a ballistic pendulum to illustrate the method of determining the unit disruptive charge of an explosion.

Two other demonstrations had to do with explosions due to lamps. In one test the effect of an explosive air and gas mixture on various "safety lamps" was shown with different velocities of the gas. In the other demonstration the globe of

open-hearth steel and also largely for re-heating purposes, while coal is used for balance of the re-heating and for steam power. Natural gas is piped from West Virginia. Coal is received at the works by both rail and river, about one-half the supply coming each way.

Raw materials so far as possible are received in yards served by overhead electric traveling cranes where electromagnets are used when convenient for handling.

The crucible melting department consists of 12 Siemens regenerative furnaces ranging from 24 pots to 48 pots each.



EXCURSION OF AMERICAN ELECTROCHEMICAL SOCIETY TO THE

an incandescent lamp was broken mechanically in an explosible atmosphere to see under which conditions an explosion would ensue. The comparative thickness of the filament was shown to be very important in this respect. When the globe of a lamp with a comparatively thick carbon filament is broken, usually an explosion results; when the globe of a lamp with a frail tungsten filament breaks, an explosion is very unlikely. Different types of mine rescue apparatus were also demonstrated.

Besides the investigation of prevention of mine accidents the Technological Branch of the U. S. Geological Survey has two other objects; the testing of structural materials (especially at present in connection with the Panama Canal and fuels.

The testing of firebrick under load conditions at 1300° C. was demonstrated and test kilns shown in operation. A test of a cable was also made on a 600,000-pound machine.

#### Thursday Excursion.

For Thursday afternoon six different excursions had been arranged, all of which were well attended.

The *Isabella* furnaces of the *Carnegie Steel Co.* are of special interest, as this is the plant in which the dry-blast process of James Gayley was first applied. The estimated saving by the use of dry blast is 360 pounds of coke per ton of iron, an increase of tonnage of 11½ per cent.

The *Park Works* of the *Crucible Steel Co. of America* is the largest individual works belonging to the Crucible Steel Company, and, when in full operation, employs about 2500 men. Its average production of finished steel amounts to 140,000 to 150,000 tons per year.

Natural gas is used for fuel in melting both crucible and

The maximum melting capacity in crucible steel ingots is about 3,000 pots of 100 pounds each in 24 hours, or about 150 net tons. In tonnage output, this crucible melting department is the largest in America and is only rivaled by that of Krupp abroad.

The open-hearth department consists of 8 furnaces, 3 "acid" and 5 "basic," ranging in capacity from 18 to 50 tons each. In this department effort has been directed toward the production of the finer grades of open-hearth steel and to specialties, rather than toward large tonnage. About 30 steam hammers and 20 trains of rolls are used in the production of the finished product. The company manufactures all their graphite crucibles from graphite brought from the island of Ceylon and from clay brought from Germany. At this works are made all the celebrated brands of "black diamond" tool steel, some of which have been on the market for nearly fifty years. The Park "extra," "special" and "silver" brands are also made here. Among the high-speed steels the "rex A" and "rex AA" brands are produced at this works. Protective shields for field guns for the United States Army, which require plates .15-inch thick to stand impact of cupro-nickel jacketed bullets from an army rifle with 2,140 ft. per second muzzle-velocity at range of 50 yards, without the plate showing any signs of crack, and only a limited amount of "bulge," are also made at this works. Alloy steels in which tungsten, chromium, nickel, vanadium, silicon, manganese, titanium and other metals are used in varying combinations and proportions, are produced extensively at this plant, as are also the composite steels made up of layers of hard and soft steel, such as 5-ply safe steel, jail bar, soft center and hard center.

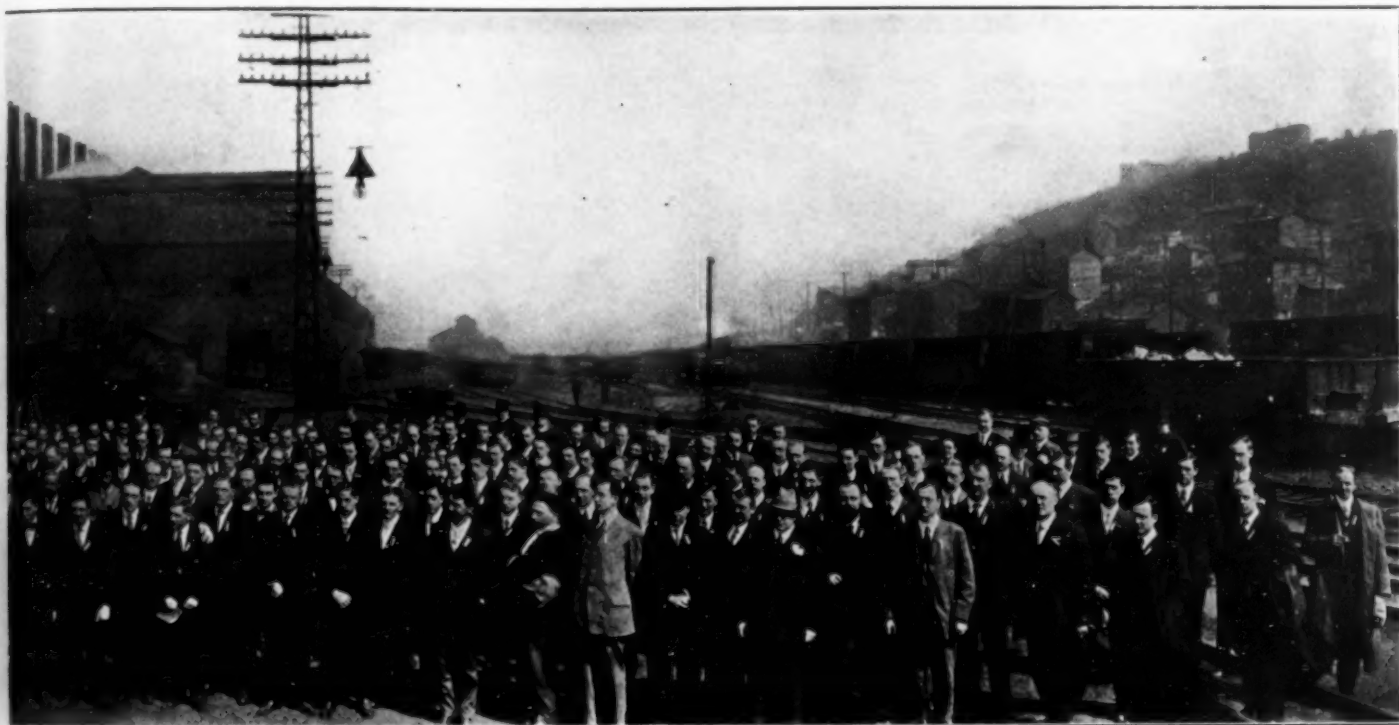
The *Jones & Laughlin Steel Co.* is the largest independent steel company outside of the U. S. Steel Corporation. The works are metallurgically of special interest on account of the nine 200-ton Talbot continuous furnaces, which the South Side open-hearth plant contains, besides seven stationary furnaces of approximately 50 tons capacity each.

The Talbot furnaces are called continuous because they are never entirely empty during a run. They may be termed basic-lined tilting continuous furnaces.

When starting the furnaces the first of the week, the charge

matte roasting furnaces, reverberatory softening (refining) furnaces and desilvering kettles for separating silver and gold from the lead bullion; zinc distillation furnaces for separating zinc from zinc-silver crusts, and cupelling furnaces for refining the silver and gold; also, beehive ovens for making coke required by the blast furnaces.

A considerable variety of ores and of products containing lead and silver are smelted here—ores from the Cobalt district in Canada, the Coeur D'Alene district in Idaho, the Middle West and other districts; and among the products are high-



HOMESTEAD WORKS OF THE CARNEGIE STEEL COMPANY.

consists of cold pig iron of low silicon content, steel scrap, burnt lime or limestone; the same as used in a stationary furnace. When the bath is in the liquid state, molten pig iron of low silicon content is taken from the mixer and added to the bath, an oxidizing slag being made by the addition of roll scale before the above metal addition. These different operations of adding roll scale, lime and metal are continuous until the bath contains 200 tons or more, when the slag and bath are made in condition for tapping; after which 60 to 80 tons are poured off into a ladle where the proper deoxidizing alloys are added and the steel is teemed into moulds.

The important part of the operation is the addition of roll scale and lime, as all the metalloids in the iron are to be oxidized chiefly by the oxygen brought in by the addition of roll scale. Experience has shown that the required amount of scale to add is about 21 to 24 per cent of the metal charged; and the lime from 6 to 8 per cent, according to the composition of the lime and scale.

After the scale has been charged in the furnace for about one hour, 30 to 60 tons of mixer-iron is poured through a trough into the furnace. The reaction takes place immediately and is somewhat like a Bessemer blow during the elimination of carbon, inasmuch as a large volume of carbonic oxide gas is driven off. When the iron oxide of the slag reacts upon the bath containing silicon, phosphorus and manganese, they are in turn oxidized, to silica, phosphoric acid, and manganese oxide, which enter the slag. The carbon is oxidized to carbonic oxide.

The *Pennsylvania Smelting Co.* at Carnegie, Pa., contains two lead blast furnaces for smelting the ore, reverberatory

grade litharge, refining lead, antimonial (hard) lead, silver, matte and speiss.

At the *Universal Portland Cement Co.* at Universal, Pa., Portland cement is made from limestone and granulated blast furnace slag, the latter being the product of the Bessemer furnaces of the Carnegie Steel Company. Large bins approached by elevated tracks at one end of the raw material mill provide the storage room for the raw material. From these bins the limestone is fed directly into gyratory crushers which prepare it for the dryers into which the stone then enters. The slag is also fed into separate dryers, all of which are maintained at a sufficiently high temperature to drive off all the moisture. After passing through the dryers each of the raw materials is conveyed into separate Ball and Williams mills, where rolling and impact reduces them to extreme fineness. The two materials are then carried to separate hoppers from which they are drawn off and properly proportioned by electrically operated weighing devices. The mixture of slag and limestone, already a powder, is then passed into tube mills where flint pebbles rolling in a steel drum thoroughly mix it and complete the process of pulverization.

The next step is the calcination of this raw mixture in rotary kilns. Leaving the rotary kilns the clinker, produced by the burning, is dropped into storage pits where it is cooled and cured. Electrically-operated cranes then carry the clinker to the finishing mill, where it is passed through jaw crushers to Kent mills and then over Newyago separators. After the addition of a certain quantity of gypsum, which is done by means of an automatic device, the material again passes through tube mills similar to those used in finishing the raw



material. Being now ground to a specific degree of fineness, the cement passes on to a belt conveyor and is distributed into the various bins of the storage house. The cement in passing from the finishing mill into the storage house is automatically sampled, from which samples the various tests for quality are made in the laboratory.

At the works of the *Nernst Lamp Co.* the processes of manufacture of the glower and the heater were shown.

The *Pittsburgh Reinforced Brazing & Machine Co.* was also visited. The methods of repairs of this company were described in an article on page 300 of our last issue.

#### Friday Excursion.

For Friday a delightful all-day excursion had been arranged, by special train.

The *Allegheny Plate Glass Co.'s* works at Glassmere were first visited. The various successive operations of casting, cooling, trimming, grinding, and finishing were most interesting. The output of this modern, up-to-date plant is 4,000,000 square feet of polished plate glass per year.

The immense works of the *Westinghouse Electric & Mfg. Co.* and of the *Westinghouse Machine Co.* were next visited. Of special interest were the large electric locomotives for the New Jersey-New York-Long Island tunnels of the Pennsylvania Railroad. For the repair of castings the Bernardo system of electric arc welding is employed on account of the simplicity of the apparatus; it is stated to give very good results and to save considerable money. At the works of the *Westinghouse Machine Co.* the Melville-Macalpine reduction gear, with floating frame for equalization of two pressures was of special interest. It permits reductions up to a ratio of 12 to 1 and capacity as high as 25,000 hp. It interlinks turbine of most efficient speed with propeller of most efficient speed for marine work. It is also especially applicable to direct-current work in connecting a turbine which is of inherently high speed with a generator that must be operated at low speed.

The *Firth-Stirling Steel Co.*, at McKeesport, was then visited. Only fine crucible steel, for tool purposes, is made at the McKeesport plant. They have installed a large number of crucible furnaces, one 2½-ton Heroult furnace and one resistance furnace. The remaining equipment is the same as found in any crucible steel works, and consists of a number of steam-driven rolls, steam hammers, and electric-driven shears, etc. Power for the motors is obtained from 1-250-kw and 1-150-kw, d.-c. generators, belted to steam engine units. The boiler house contains a bank of six boilers, aggregating some 1800 hp. Of special interest is the 2½-ton Heroult electric arc furnace. In its general design it is just like the 15-ton Heroult furnace, at South Chicago, described in our April issue, page 179, but smaller and operated by single-phase instead of three-phase. It is operated with cold charge. Three heats can be refined, working from cold scrap for 24 hours, and probably 15 heats when working with hot material from the open-hearth furnace.

There is also a simple 120-kw resistance furnace for ferro-alloy manufacture at these works.

The famous and magnificent *Homestead Works of the Carnegie Steel Co.* was the last plant visited. They are so well known that no description is necessary.

It should be mentioned, however, that an electric furnace is now running at these works of 25 tons capacity. Its feature is that it can be used either as open-hearth or electric furnace.

It is first used as an open-hearth and when the heat is finished the gas supply is closed, the electrodes are lowered and the electric refining process begins. The advantage of this arrangement is that the transfer of molten metal from an open-hearth to an electric furnace is avoided. The disadvantage is the complication of the roof construction.

The party then returned to Pittsburgh.

In the following we give a complete alphabetical list of the

names of members and guests in the last printed registry list. Where no city is stated, Pittsburgh is meant:

G. P. Adamson, Easton, Pa.; I. C. Allen; R. Amberg, Chicago, Ill.; R. Anderson, Philadelphia, Pa.; W. C. Andrews, New York; R. B. Anthony; J. C. Armor, Ingram, Pa.; Mr. and Mrs. W. C. Arsen, Schenectady, N. Y.; J. Aston, Madison, Wis.; R. W. Atkinson; G. H. Aupperle, Avonmore, Pa.; J. A. Aupperle, Middletown, Ohio; J. E. Babb; H. Bacharach; A. E. Bachert, Tyrone, Pa.; Dr. and Mrs. Leo H. Backeland, Yonkers, N. Y.; Charles Bailey; F. D. Barbour; H. Barbour; W. E. Barnes, Creighton, Pa.; J. M. Barrett; A. M. Barron, Cleveland, Ohio; G. C. Bauer; J. W. Bechman, Niagara Falls, Ont., Canada; J. Bechtel, Tarentum, Pa.; A. W. Belden; H. Beltz, Perry, N. Y.; J. C. Bennie, New York City; P. McN. Bennie, Niagara Falls, N. Y.; G. H. Blaxter, Beaver Falls, Pa.; A. D. Bleinenger; E. Blough; P. A. Boeck, Worcester, Mass.; G. Boericke, Primos, Pa.; J. J. Boyle, Ambridge, Pa.; Wm. Brady, Chicago, Ill.; J. D. Breneman; A. Brill; W. H. Bristol, Waterbury, Conn.; Mr. and Mrs. B. E. Broadwell, Cleveland, Ohio; Mr. and Mrs. W. B. Brookfield, Syracuse, N. Y.; G. H. Brown; J. T. Brown; J. W. Brown, Cleveland, Ohio; Jos. Brown; R. C. Brown, Greensburg, Pa.; Mr. and Mrs. C. L. Bryden, Scranton, Pa.; N. M. Buch, West Pittsburgh, Pa.; R. V. Buigay; H. R. Bulmer, Alliance, Ohio; C. F. Burgess, Madison, Wis.; W. K. Burrows, Harrison, N. J.; J. R. Cain, Washington, D. C.; A. R. Calder, Steelton, Pa.; J. D. Callery; C. B. Callomon; H. R. Carveth, Niagara Falls, N. Y.; C. R. Cary, Philadelphia, Pa.; A. Casselberry, Altoona, Pa.; Adolph Challas, London, England; G. D. Chamberlain; W. P. Champney, jr., Cleveland, Ohio; D. H. Childs, Alfred, N. Y.; R. B. Chillas, jr., Cleveland, Ohio; G. B. Chorpene, Clarksburg, W. Va.; E. C. Chrisown; C. C. Cito, Newark, N. J.; Mr. and Mrs. E. B. Clarke, McKeesport, Pa.; J. K. Clement; Mr. and Mrs. W. R. Clymer, Cleveland, Ohio; W. C. Coffin; W. P. Cohoe, Toronto, Canada; E. A. Colby, Newark, N. J.; F. Collins; Wm. F. Colman; A. L. Colton; H. R. Connell; Sidney Cornell, Duquesne, Pa.; Mr. and Mrs. J. S. Coye, Boston, Mass.; Prof. and Mrs. F. Crabtree; H. H. Craver; F. S. Crawford; J. S. Crider, Cleveland, Ohio; F. H. Crosby, Oakmont, Pa.; W. B. Crowe; A. W. Crownover, Greensburg, Pa.; C. W. Danforth, Sharon, Pa.; G. H. Danforth; H. E. Davis; W. B. Davis; S. A. Davis; S. Davis, Jr.; A. H. Dean; B. Dewey, Vandergrift, Pa.; Colby Dill, Perth Amboy, N. J.; H. E. Diller, Schenectady, N. Y.; W. A. Donkin; C. A. Doremus, New York; J. W. Dougherty, Steelton, Pa.; H. Dripps; H. DuBois, New York; S. N. Dunbar; L. H. Duschak, Corning, N. Y.; Saul Dushman, Toronto, Canada; J. J. Eckfeldt, Latrobe, Pa.; D. Edge, Swissvale, Pa.; H. R. Edgecomb; A. D. Edwards; H. F. Engelbrecht; H. W. Erbing; F. F. Farnham, McKeesport, Pa.; G. Feskes; J. J. Flannery; G. H. Follows; C. S. Foster, Rochester, N. Y.; J. L. Foster; M. W. Franklin, Schenectady, N. Y.; J. W. C. Fraser; E. Friedlaender, Braddock, Pa.; H. Frodsham, Schenectady, N. Y.; H. A. Field; A. C. Fieldner; C. G. Fink, Schenectady, N. Y.; C. G. Fisher; Mr. and Mrs. H. W. Fisher; H. L. Fullerton; H. A. Gardner, Philadelphia, Pa.; Mrs. Gass; André Gerard, Liège, Belgium; J. A. Gerhart; C. L. Gerwig; W. H. Gibbs; A. E. Gibbs, Wyandotte, Mich.; Miss Gibbs, Wyandotte, Mich.; Mr. and Mrs. W. T. Gibbs, Buckingham, Quebec; C. B. Gibson, Wilkinsburg, Pa.; H. W. Gillett, Ithaca, N. Y.; J. S. Goldbaum, Philadelphia, Pa.; S. L. Goodale; G. M. Goodspeed, McKeesport, Pa.; J. H. Goodwin, Fremont, Ohio; S. P. Grace; C. M. Graves, Fostoria, Ohio; J. M. Graves; W. G. Graves, Cleveland, Ohio; A. E. Greene, Chicago, Ill.; J. H. Grove, Homestead, Pa.; R. S. Guerber; H. R. Hadfield; H. Halcomb; J. Hall, Tarentum, Pa.; Carl Hambuechen, Madison, Wis.; J. O. Handy; C. A. Hansen, Schenectady, N. Y.; Mr. and Mrs. R. H. Hartley; N. Hecht; H. W. Heinz; C. T. Henderson, Milwaukee, Wis.; E. Hensen, McKeesport, Pa.; Carl Hering, Philadelphia, Pa.; Dr. P. L. T. Heroult, La Paz, France; P. H. 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Koethen; M. M. Kohn, New York; C. R. Krueger, Schenectady, N. Y.; Dr. R. Krulla, Vienna, Austria; E. F. Lake, New York; A. B. Lamb, New York City; H. G. Lamker; H. M. Lane, Cleveland, Ohio; J. Langton, New York; Mr. and Mrs. H. C. Landbeck, Wilkinsburg, Pa.; Mr. and Mrs. H. H. Laughlin; E. J. Lavino, Philadelphia, Pa.; G. H. Leeds; Robert B. Leighton, Northumberland, Pa.; J. D. Lewis, Braddock, Pa.; F. A. Lidbury, Niagara Falls, N. Y.; Mr. and Mrs. P. M. Lincoln; W. B. Lindall, Toronto, Canada; D. H. Littell; M. G. Lloyd, Chicago, Ill.; Chas. Longanecker; F. H. Loveridge, Chicago, Ill.; A. Lowenstein, Chicago, Ill.; C. W. Lytle, Sharon, Pa.; J. K. Lyons; W. L. Macloskey; Gordon E. Marble, Schenectady, N. Y.; S. J. Marchan; C. W. Marsh, New York City; J. P. Martin; E. J. K. Mason; H. V. Mason; J. E. Maten; F. L. May, Steubenville, Ohio; W. A. McCaffey; E. H. McClelland; W. M. McConahay; W. H. McCune, Vandergrift, Pa.; R. A. McDonald; J. H. McFeely; J. N. McIlvaine; F. F. McIntosh, Sewickley, Pa.; T. McIntosh; W. N. McKee, Chicago, Ill.; Jos. McKinley; J. E. McKirdy; W. N. McKnight; D. J. McLaughlin, Munhall, Pa.; C. A. Menk, Munhall, Pa.; E. S. Merriam, Marietta, Ohio; J. L. Merrill; K. S. Miller; H. S. Miner, Gloucester City, Pa.; G. B. Mitchell; Miss R. J. Mitchell; I. D. Mooney; L. A. Moran; W. P. Morvan; C. H. Moritz, Niagara Falls, N. Y.; E. K. Morse; W. R. Mott, Cleveland, Ohio; J. M. Muir, New York; Mr. and Mrs. H. N. Müller; D. H. Murphy; S. Myasaki; H. A. Neel, Dravosburg, Pa.; George Neilson, Oakmont, Pa.; A. B. Norton, Jr.; Mr. and Mrs. J. E. Ober; J. A. O'Callaghan; D. L. Ordway, Cleveland, Ohio; R. S. Orr; L. A. Osborne; G. S. Page; L. R. Palmer; F. L. Parker, Philadelphia, Pa.; C. W. Parkhurst, Johnstown, Pa.; L. A. Parson, Gettysburg, Pa.; A. C. Parsons, Buffalo, N. Y.; Wm. C. Parsons, Braddock, Pa.; R. S. Perry, Philadelphia, Pa.; N. Petiot, Niagara Falls, N. Y.; A. Pinkerton; F. B. Porch; H. C. Porter; E. P. Poste; A. L. Queneau, Philadelphia, Pa.; K. C. Randall; H. S. Randolph; J. C. Reed, Steelton, Pa.; R. C. Reed, Duquesne, Pa.; W. E. Reed; P. P. Reese, Munhall, Pa.; C. R. Reicher; C. R. Rhodes; C. H. Rich, Clearton, Pa.; Jos. W. Richards, South Bethlehem, Pa.; H. K. Richardson, State College, Pa.; H. K. Rigdon; C. D. Robb, New York; J. C. Roberts; H. Rodman, East Pittsburgh, Pa.; E. F. Roeber, New York; A. G. Rogers, Niagara Falls, N. Y.; F. M. Roller, New York; F. Rose; W. J. Rouch; T. Rowland, Niagara Falls, N. Y.; H. H. Rudd; Louis Ruhl, New York; D. J. Russian; B. Rutherford; S. S. Sadtler, Philadelphia, Pa.; B. D. Saklatwalla; L. E. Saunders, Niagara Falls, N. Y.; W. M. Saunders, Provi-

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### Notes on Chemistry and Metallurgy in Great Britain.

#### The Rubber Outlook.

The synthetic production of rubber is being keenly discussed in London amid the incentives of phenomenally high prices (300 to 400 per cent above those of 10 years ago), an avalanche of flotations of rubber companies (many of the wildcat order), to say nothing of inflated share prices and wildly reckless gambling. The elements of danger to the industry are numerous—synthetic rubber not least of all. Everybody is talking of it, and quite a number of people have actually in their possession strips of rubber alleged to have been produced in the laboratory. Some samples which the writer has examined are so similar in their visual appearance to plantation rubber as to call to mind the way in which a prominent financial magnate was hoodwinked over the artificial production of diamonds in Paris a year or two ago.

The daily talk about synthetic rubber is becoming keen, and one hears of ounces being produced. The cost of production is mentioned as ranging from 1 to 10 shillings per pound for materials alone. Nothing is yet stated to have reached the practical stage, practical being defined as the making of 25 lb. or 100 lb. lots. There is, therefore, the danger of rubber planting being hit as hard as indigo planting has been hit by the success of the chemist. All this is being ridiculed by the officials of the various companies.

Other dangers lie in insect pests or fungoid diseases, for nature seems to be quite capable of producing the equivalent of the cotton boll weevil.

Overproduction must also be regarded as the certain outcome of a few years hence. It is even possible at an earlier date, as the present high prices are an incentive to the extensive collection of large amounts of rubber from the wild trees. If this be on the reckless scale which has reduced the West African output through overtapping, this will ultimately bring more harm than good. The tapping of immature trees is also a likely possibility on a number of the plantations.

Up to the time of writing these words there are no signs of a retrogression in the price of rubber itself. There are fortunately signs that the investing mania has reached its zenith.

#### Faraday Society.

The visit of Professors Walden and Guye to the meeting of the Faraday Society, to read papers giving their latest investi-

gations into the "Constitution of Water," was the occasion for a very pleasant gathering at the Trocadero Restaurant on April 26. The distinguished foreign guests were entertained to dinner by the society, this being the first dinner ever held by this body. About 45 members were present, and the guests included Sir Wm. Ramsay, K.C.B., F.R.S.; Sir Wm. Jilden, F.R.S.; Dr. Wilmore and Sir Joseph Larmor.

As Mr. Blount remarked, in proposing the health of Sir Wm. Ramsay, it was difficult to say who were guests and who hosts, so thoroughly was the whole company in sympathy. In returning thanks for the toast of his health Professor Walden, who spoke first in English and then in German, after a modest disclaimer of his ability to render his meaning clear in English, the reason for which was not apparent, made feeling reference to the good work effected by science in overcoming national differences, and providing a common meeting ground for the natives of all civilized countries. He attributed the introduction of chemical knowledge into Russia to an Englishman, Pegram, and cited the many well-known names illustrious in the annals of chemistry which have belonged to natives of this country.

Professor Guye, who spoke in French, referred to the early years of Faraday, who had studied under a Swiss, and may be said to have first had his genius appreciated by a member of that nation. The toasts of the "Associated Societies" was responded to by Dr. N. T. M. Wilmore, president of the Chemical Society, who referred to the growth of the Faraday Society and made appreciative remarks on the papers of the evening before.

The president of the society, Mr. James Swinburne, F.R.S., past-president of the Institution of Electrical Engineers, referred to the work done by Mr. Sherard Cowper-Coles in founding the society, which was intended more particularly for the study of electrochemistry.

#### Nitrogen in Mild Steel.

Mr. C. E. STROMEYER, in a paper presented at the spring meeting of the Institution of Naval Architects on "The Brittleness of Mild Steel Due to Nitrogen," said that until quite recently nothing was known with regard to the effect of nitrogen on steel in causing brittleness. For phosphorus 0.060 per cent was considered to be a reasonable limit, and steel plates containing more were open to suspicion. This view had now to be modified. One sample which the author had tested, which was undoubtedly of very bad quality, contained only 0.047 per cent of phosphorus, but it also contained 0.0123 per cent of nitrogen, which was more than twice as much as that contained in any good steels. Another sample, from a boiler plate which burst under hydraulic test, contained only 0.052 per cent of phosphorus, but 0.0200 per cent of nitrogen, or four times as much as is contained in good steels.

Nitrogen had 10 times the effect of phosphorus in raising the tenacity of steel: an addition of 0.01 per cent increasing the tenacity by nearly three tons. A safe rule was that the sum of the percentage of phosphorus plus five times the percentage of nitrogen should not exceed 0.080 per cent.

No investigation into the cause of failure of a mild steel plate could be considered complete unless both the phosphorus and nitrogen had been determined. The nitrogen determination was simple and rapid, but precaution had to be taken to guard against absorption of ammonia. Some continental angle irons intended for small portable locomotive boilers failed in the boiler shop; they contained 0.0146 per cent of nitrogen, and portions of a damaged furnace plate proved to be quite brittle. The nitrogen was 0.0180 per cent. Fractured steel plates from a ship being built in a continental port, which plates had been tested and passed, contained 0.023 per cent of nitrogen. These percentages were from three to five times as great as the maximum found in any good steels.

As to how the nitrogen got in the steel, it had not been found possible to combine nitrogen with steel by heating the two together; and the only known means of effecting combina-



tion was to heat steel in an atmosphere of ammonia. The nitrogen probably entered the pig iron in the blast furnace, and could not be removed by subsequent heating. The addition of ferrotitanium alloy to steel had not demonstrated that titanium affected the removal of nitrogen. Nevertheless, a strong argument in favor of the belief that titanium could reduce the percentage of nitrogen was recently brought to the author's notice by the discovery inside the dismantled blast furnaces of the Farnley Iron Company of some crystals of titanium nitride, which were now in the Leeds Museum.

#### Switch and Transformer Oils.

At the meeting of the Manchester Local Section of the Institute of Electrical Engineers, on March 22, a paper on the properties of "Switch and Transformer Oils," by Mr. W. POLLARD DIGBY and Mr. D. B. MELLIS, was read. The authors considered that oil for switch and transformer use had not received sufficient care in its selection nor due investigation during its use. The electrical engineer relied on the literature of the firms supplying oils of this character, and it was by no means certain that the whole of a consignment would be equal to the special sample submitted.

The properties they regarded as requisite were absence of moisture; good dielectric strength; a low viscosity, to facilitate the transfer of heat from the core and windings to the case; a flash-point at a temperature two or three times that of the designed limit of the transformer; a perfectly neutral reaction; absence of vegetable oil or resinoid matter; and free from metallic compounds.

The authors had found that specific resistance was a very good index of purity. They determined the resistance between a pair of metallic disks, the distance between which was regulated by a micrometer screw, taking readings on a "megger" or other kind of ohmmeter. Of a series of six typical oils, the variation was from about 600,000 megohms to 6.5 million megohms per c.c.

For dielectric tests electrodes consisting of a point and a disk were found to answer best; and the authors described at considerable length their tests of oils as received and after baking. Baking was found to increase the dielectric strength where this was less than 10,000 volts. The specific resistance for oils of high resistance was not increased, but where a lowered specific gravity indicated evaporation of moisture there was an increase. Generally there was increase in specific gravity and viscosity, with some raising of the flashing point.

The authors gave detailed descriptions of all the physical and chemical tests which they considered necessary for the complete examination of oils. Results of tests undertaken to investigate changes produced in oil switches by 200 breaks of a definitely known current went to show that a switch could be tripped a very great number of times before the properties of the oil perceptibly deteriorated. The amount of carbon produced by prolonged arcing was also determined in several samples, and was found to vary with the physical and chemical properties. The authors also suggested that specific resistance measurements might be taken in a series of heating and cooling curves to determine the point at which certain molecular regrouping of the hydrocarbons seem to occur.

#### The Classification of Steels.

The proposals of the committee of the International Association for the Testing of Materials with regard to the definitions of iron and steel have not been favorably received in Sheffield, where the prevalent opinion is that those proposals, if adopted, will be prejudicial to the status of the best class of Sheffield products and will open the door to malpractice.

The committee recommended that the term "blister steel," which is restricted to cemented Swedish wrought iron or wrought iron of equal quality, should in future include "steel made by carburizing wrought iron by heating it in contact with carbonaceous matter, which may also be made by carburizing

a low carbon steel," and an important meeting of Sheffield manufacturers was held on April 19 to consider the question.

Professor Arnold indicated the effect of the adoption of the proposal in facilitating the introduction of inferior metal into the trade, and demonstrated that ultimately, not only would the quality of blister steel be involved, but both sheer and crucible steel would be degraded. A committee was appointed to protect the interests of the crucible-steel trade and to communicate with the International Committee.

#### The Action of Sewage on Concrete.

Mr. SIDNEY H. CHAMBERS, at the last (April) meeting of the Concrete Institute, stated that his experience at Hampton sewage works did not support the widely accepted opinion that no marked disintegration need be anticipated in sound concrete either from sewage or its emanations. The concrete in question consisted of one part Portland cement and six parts of clean ballast. A few months after the tank was put into use the concrete roof and walls of the hydrolysing chambers, above the level of the sewage liquid, became covered with a chalky-looking efflorescence which was easily removed and was found to be mainly sulphur. Subsequently the walls and roof of the second part of the tank exhibited signs of peeling and disintegration.

The first part of the tank—the hydrolytic chamber—had only the slight deposit of sulphur and a slight erosion at the liquid level; but in the second part—the hydrolysing chambers—the action was much more marked, and on removing the eroded surface the underlying concrete was found to be moist, soft and gritty. The greatest effect was at the varying liquid level and depended upon the quantity of sulphuretted hydrogen in solution. There was comparatively little of this gas at the intake or in the hydrolytic tank; but its amount increased in the liquid passing through the hydrolysing chambers.

With a varying level the concrete was left moistened with a film of liquid containing sulphuretted hydrogen which was oxidized by the air, and thus sulphur was liberated and sulphuric acid produced, the result being that the lime in the cement was finally converted into calcium sulphate. The intermediate product of the oxidation of the sulphuretted hydrogen was probably sulphurous acid. As the liquid level rose the decomposed concrete was washed away and a fresh surface was exposed to the action when the level fell.

The investigation indicated that the gases dissolved in sewage and those emitted from it acted injuriously on Portland cement when there were (1) a high degree of putrescence of the sewage; (2) a moistened surface retaining or absorbing the gases resulting from putrefaction; and (3) a free supply of air; but that in the absence of any one of these conditions serious erosion was not to be feared.

#### Plating Powders.

A preparation which is being extensively advertised and was the subject of a paper read before the Society of Arts on Feb. 2, 1910, exemplifies the truth of the saying "there is nothing new under the sun." An old book of recipes, dated 1823, gives a formula for silvering by a mixture of silver chloride, salt and cream of tartar, to be rubbed on the surface of the article to be plated.

In the *Chemist and Druggist* of July 15, 1881, appears the following formula for an "instantaneous silvering powder": Silver chloride, three parts; cream of tartar, 20 parts; sodium chloride, 75 parts; mix. Moisten a portion with water, and with a piece of blotting paper rub it on the clean metallic object, which is to be rubbed with a piece of cotton on which precipitated chalk is dusted; wash with water, and polish with a dry cloth.

In Cowley's "Encyclopedia of Practical Recipes," sixth edition, Vol. 2, page 1456, appears a similar formula with the addition of whiting (purified chalk). It is within the writer's experience that these recipes easily and quickly produce a film

of metallic silver on brass and copper articles, but the thickness of the coating is so slight that the process would be of little use for articles exposed to any degree of wear.

The material recently put on the market differs from the powders referred to above by the addition of magnesium powder to act as a positive element; and this difference appears to constitute the essential feature of the patents which have been secured.

#### Market Prices.

*April, 1910.*—Copper has shown a downward tendency throughout the month. Starting at £58 it fell after the 7th, reaching £55.5.0 on the 26th, thence recovered to £56.3.9.

Tin has been irregular, dropping away from the opening £152, and touching £147.15.0 on the 13th. Closes at £148.

English lead slight decline during the first week, thence steady, closing at £13.

Hematite opened at 68/7½, rose in the course of a week to 68/9, thence declining to a final price of 67/1½.

Iron, Cleveland warrants, rather jerky, commencing 51/6, dropped by the 13th to 51/-, and by the 25th to 50/6. Present price (29th) 50/3.

Scotch pig, following the same line as Cleveland, opened at 57/6 and closed at 56/3. Downward tendency throughout the month.

	£.	s.	d.
Aluminium ingots in ton lots.....	80.	0.	0
Ammonia—alum, lump, loose.....	5.	12.	6
Antimony black sulphide powder, per ton.....	20.	0.	0
Borax, best refined crystal, per ton.....	16.	0.	0
Sulphate of ammonia, f.o.b. Liverpool.....	12.	2.	6
Sal-ammoniac, lump, first delivered U. K.....	42.	0.	0
Copper sulphate.....	18.	0.	0
Camphor, 1 oz. tablets.....	1.	7	
Caustic soda, 48 per cent ordinary.....	5.	10.	0
Bleaching powder, 35 per cent.....	4.	5.	0
Shellac, Standard, T. N. Orange Spot, per cwt....	3.	10.	0
Sulphur, recovered, per ton.....	5.	0.	0
Carbolic acid, liquid, 97/99 per cent, per gal.....	1.	0	
Hydrochloric acid, per cwt.....	5.	0	
Creosote, ordinary good liquid, per gal.....	2¼		
Naphtha solvent, 90 per cent at 160° C., per gal....	1.	4½	
Rubber, Para, fine, per lb.....	11.	10	
Platinum, per oz.....	6.	0.	0
Zinc, sheet (Vieille Montague brand).....	26.	15.	0

Rubber is still engrossing the attention of the Stock Exchange. Fine Para, which opened at 10/5½ per pound, rose steadily to 11/4½, then to 11/8, and touched at mid-month 12/3. It subsequently declined to 11/10.

There is an obvious shortage of this material, which appears to have been coming on for nearly two years. Extensive planting in the Malay Peninsula has been encouraged by present prices, and over 100 companies interested in rubber have issued prospectuses since Jan. 15. Very large prices are at present being given for shares. A fall in the price of these securities would not necessarily entail cheaper rubber, although possibly the reaction might check the demand for a time. Speculation can have little influence on the actual commodity itself. Of the other prices it will be noted that aluminium has risen, while the other metals, with the exception of platinum (always a rather vague price), are inclined to fall off.

Naphtha solvent again moves upward, presumably in sympathy with oil.

*London, April, 1910.*

**Ductile Tungsten.**—At an A. I. E. E. meeting on May 27, Dr. W. D. Coolidge, of the Research Laboratory of the General Electric Company, read a paper on ductile tungsten, which is printed in the June issue of the *Proceedings*.

## SYNOPSIS OF METALLURGICAL AND CHEMICAL LITERATURE.

### Iron and Steel.

**Case-Hardening.**—A paper by Mr. SYDNEY A. GRAYSON, presented at the May meeting of the Iron and Steel Institute, gives an account of "some recent investigations on case-hardening." The author shows that it is necessary to classify case hardening compositions, both by the carbon percentage obtained in the "case" and also by the graduation of the carbon diffusion, which is best shown graphically. This classification is necessary on account of one composition being more suitable for certain kinds of work than another. A high carbon "case," such as 1.10 per cent centigrade would be very efficient for the kind of work where the pressure was fairly constant, such as a plain bearing, but it would be very unsuitable and inefficient for parts which had to resist repeated shocks, because of the strong tendency of the high carbon "case" to chip or even to peel off. Consequently, it is advisable, where all kinds of case-hardening have to be done, that two compositions be used—one of them to produce a high-carbon "wearing surface" and the other to produce a medium-carbon "wearing surface." On the other hand, for a composition to be used for "general" purposes, it should produce a "wearing surface" containing a percentage of carbon equal to that of the eutectoid 0.9 per cent in order to give the most efficient results.

The evidence obtained from the author's results respecting the carburizing temperature shows that the best temperature is 950° C. to 1000° C., although the high temperature 1000° to 1050° can be used with advantage in some cases. The results obtained at 900 C. to 950° C. tend to show that although there is an active carburizing atmosphere produced in the box the temperature of the steel is only high enough to allow of a slow diffusion of the carbon, consequently supersaturation of carbon takes place at the surface of the steel.

Diffusion of the sulphur seems to proceed in a similar way to that of the carbon at the temperature of 900° C. to 950° C. and 950° C. to 1000° C. All charred leather material does not contain this active amount of sulphur, although the sample used by the author was obtained from a well-established firm, and was used in this investigation in order to find out, if possible, the cause of a soft skin, which was always produced under certain conditions by this material, of which this sulphur diffusion is the most probable explanation. The brown scintilla material contains a fairly large amount of sulphur, and which exists chiefly in the sulphide form, although it does not seem to act by any means as keenly as the sulphur in the charred leather material. This is most probably due to Scintilla material having a high percentage of volatile hydrocarbons, which carries off the effective part of the sulphur with it. (From advance sheets.)

**Steel for Gears.**—Mr. LOUIS P. M. REVILLON has tested the leading types of steel offered by French manufacturers for the construction of gears (especially speed-change gears for motor vehicles) and also products supplied from two German steel works. The results are given in the *Iron and Steel Institute Carnegie Scholarship Memoirs*, Vol I, pages 161 to 218. In the whole 26 steels were tested, which are divided into four classes. I, steels which contained neither nickel nor chromium; they were, generally speaking, manganese-silicon steels; II, nickel-chromium steels with low percentages of nickel and low and medium percentages of carbon, quenching in water or oil; III, nickel-chromium steels with low percentages of nickel and higher percentages of carbon, quenching in oil and sometimes even in air; IV, steels with a medium percentage of nickel, either with or without chromium and a variable percentage of carbon; they were frequently capable of undergoing air quenching. "Some of these steels were made by the open-hearth process, in large quantities; others were made in crucibles alone, while finally the electric furnace, being now not infrequently in



use for obtaining high-class steels, several of the samples employed in the experiments came from firms which employ this method of manufacture."

The following conclusions are reached: It is possible to find among either class of sample a steel more or less suitable for use in making gears. Steels not containing nickel are commercial products which can be obtained at low cost, and can be made, after treatment, to give hard gears, but have relatively a high degree of brittleness. They have been much in favor, but they require complicated heat treatment and manipulation closely adjusted to their composition.

Soft nickel-steels quenched in water are insufficiently hard, but they are susceptible of being case-hardened and then furnish products of superior quality.

With an increasing percentage of carbon it is possible to find steels quenching in oil or in air, the properties of which as regards resistance to shock and the elongations of which are increased by the presence of nickel.

When the percentage of nickel is increased it is possible to obtain, with a well-adjusted carbon percentage, a steel which, with a simple treatment, will yield the best results. Annealing should, however, be very carefully conducted in order to soften the metal well for the purpose of machining, while after having completely finished the piece air quenching will suffice to insure good hardness and good resistance to shock. The great defect of these steels is their extreme sensitiveness to the smallest variations in composition. They require the greatest watchfulness in the metallurgical works in order to yield the results one is justified in expecting to obtain.

Apart from the steels of the first class, for which a complicated heat treatment is necessary, it is always possible to find, among nickel-steels, a steel corresponding in properties to all the requirements of a specific manufacture and requiring but simple treatment; that is to say, capable of being used after simple quenching without subsequent annealing—annealing being from the industrial point of view impossible to define scientifically, and difficult to adjust uniformly from one piece to another when the volume of the piece is altered.

**Special Ternary Steels; Shearing Test; Electrical Resistance.**—An extended investigation of two problems of the theory of special ternary steels, carried out by Mr. ALBERT M. PORTEVIN, is reported in the *Iron and Steel Institute Carnegie Scholarship Memoirs*, Vol. I, pages 230 to 364. The first problem discussed is the application of shearing tests to the special steels with the object of ascertaining the influence of the elements added on the results of these tests and of examining their relation to tensile tests. Nickel-steels, manganese-steels, chromium-steels, tungsten-steels, aluminium-steels, molybdenum-steels, vanadium-steels, titanium-steels, boron-steels and tantalum-steels were tested, and the principal conclusions reached are as follows: The results on shearing are, like those of the tensile tests, influenced to a considerable degree by the structure, and may serve to distinguish the different types of steel, e.g., pearlitic, martensitic, polyhedral, etc. The shearing test may, therefore, serve like the tensile test to classify these steels. If it is asked whether the shearing test is capable of replacing the tensile test, the answer will be that it would be necessary that there should be in existence formulæ correlating for all these steels the characteristic results of the tensile tests with those of shearing. To establish a relation between the tensile and shearing tests of special steels, it is necessary to take into account: (1) The nature of the element added to the steel; (2) the structure of the steel, and (3) the limits of tensile strength within which the formula becomes applicable.

It is beyond contest and the general appearance of the curves demonstrate the fact that the characteristics of the tensile tests and those of shearing depend upon variables common to both, but the formulæ becomes complicated by reason of the intervention of other variables, which differ in each case, and the influence of which may render any simple relation, applicable to

a wide range of steels, impossible. Although the shearing tests does not admit of the supersession of tensile testing, it does not follow that it is inferior to the latter. On the contrary, it brings out other properties, and, in addition to the advantages resulting from the ease with which the test piece can be prepared, it possesses the superior advantage, allows of the homogeneity of the metal being ascertained, owing to the small size of the test pieces and the possibility of renewing the test on sections close together, thus eliminating the influence of local defects, whereas the tensile test only yields an average result. This is evidently an important consideration from the point of view of the application to be made of the steel, but a disadvantage from the point of view of research because of the intervention, pell mell, of a host of factors; the inequality in chemical composition and in the heat treatment of the sample, and all the special accidents, cracks, hollows, etc., which help to falsify the results. The test has nevertheless its own particular application, which is both old-established and widespread.

The second problem discussed by the author is the electrical resistance. The same steels as mentioned above were tested and the most significant fact which is brought out is that the laws as to the variation in the specific electrical resistance of the ternary steels, with the amount of the added element, undergo fairly sudden changes corresponding with alternations in the microstructure, and that if these laws be plotted as curves they can, generally speaking, be separated into a certain number of rectilinear portions, the weak curvature of each of which is characteristic of a definite micrographic condition of the steel, pearlitic, martensitic, polyhedral, or accompanied by the appearance of a double carbide. There are two appendices following the paper dealing with the influence of vanadium and titanium on the transformation points of steel.

#### Gold and Silver.

**Cyaniding Sulphide Concentrates.**—In the March 19, 1910, issue of *Min. & Sci. Press*, A. E. DRUCKER describes his method and device for cyaniding sulphide concentrates as worked out in Korea. He uses a combined air-agitation and continuous leaching vat which embodies the good points of other apparatus which the author has seen in various countries. His original feature consists in the plow used to keep the bottom filter free from slime-cake so that the leaching and filtering process can be continuous. The dimensions of the vat are, for 10 tons, 6 ft. x 15 ft.; 20 tons, 7 ft. x 25 ft.; 40 tons, 8 ft. x 35 ft. The smaller dimensions are diameters and the larger are the heights of the tanks.

The sulphide concentrates are slimed in tube mills, and the pulp fed to the vats is about 1 to 1 by weight. The agitation and plowing device is in the bottom of the vat and the operating mechanism located beneath and outside. The filter cloth is about 6 in. above the bottom of the tank and is supported by a bottom of 3-in. boards bored with 1-in. holes. Over the filter cloth is placed a 1/8-in. sheet-iron cover, perforated to correspond with the wooden filter bottom. The revolving plows can be raised or lowered and traverse the sheet-iron plate, keeping it clear of slime, which cements very strongly in the case of sulphides. Compressed air for agitation is delivered through each plow shoe and is thus evenly distributed at the bottom of the vat and keeps the charge agitated. Filtration proceeds constantly, the filtrate going to process for clarifying. When the pulp has been reduced to about 30 per cent moisture, barren cyanide washes are introduced through the same orifices that carried air and the charge is thus thoroughly washed. Pressure filtering then proceeds as before until the pulp has about 30 per cent moisture, when it is discharged to filter presses and given a weak wash. The following figures are given for a 40-ton vat and a 4-day treatment.

#### Forty-Ton Charge.

#### Horse-power.

For driving short arms (intermittent power). 1

Air agitation (15 cu. ft. air per minute at

26-lb. pressure; intermittent power).... 1 1/2

Total intermittent power.....	2½
Continuous power.....	2
Continuous power per ton treated.....	0.05

The operations can be divided as follows after all-slitting the sulphide within a tube mill in cyanide solution, taking for example a four-day treatment:

1. Collecting a full charge in agitator (undergoing an air agitation and leaching while filling), 24 hours.
2. Air agitation and continuous leaching (cyanide solution carrying gold and silver, continuously flowing to the zinc boxes; pulp finally pressure-filtered down to 30 per cent moisture before washing), 36 hours.
3. Intermediate barren cyanide wash (mixing and finally pressure-filtering down to 30 per cent moisture before sending to filter press), 12 hours.
4. Filter-pressing, weak wash, discharging, 24 hours.

Total, 4 days.

#### ANALYSIS OF SULPHIDE SLIME TREATED IN KOREA.

No. 1 Sulphide.		Per Cent.
Iron pyrites (FeS <sub>2</sub> ).....	56	
Galena (PbS).....	36	
Sphalerite (ZnS).....	6	
Arsenopyrite (FeAsS).....	2	
		100
No. 2 Sulphide.		Per Cent.
Arsenopyrite.....	72	
Marcasite.....	27	
Galena and Sphalerite.....	1	
Copper pyrites.....	traces	
		100

No. 1 sulphide carries from \$40 to \$50 in gold and yields from 92 to 94 per cent extraction in four days. The old method of leaching for 18 days yielded an extraction of 84 per cent. No. 2 sulphide carries \$20 to \$30 in gold and yields 92 per cent extraction in four days, as against 70 to 75 per cent in 16 days by the old treatment of leaching in shallow vats.

The author gives five points to be observed in the cyanidation of sulphide concentrates: (1) To be treated when fresh and reground in tube mills with strong KCN solution. (2) To be air-agitated and aerated in a combined agitator and leaching vat for 20 to 36 hours. (3) To provide for continuous filtration so that at the end of the treatment the bulk of the cyanide solution has been precipitated in the zinc boxes. (4) To preserve the protective alkalinity of the solution and keep the cyanide strength up to 0.25 per cent KCN. Use KCN in preference to NaCN where air agitation is employed. (5) Do not allow the cyanide solution to become so foul as to become inactive.

#### Copper.

**Methods of Analysis.**—In the *Mining World* for April 2, 1910, Mr. EVANS W. BUSKETT gives details of the methods of analysis used in the laboratories of the Cananea Consolidated Copper Company. Methods are given for furnace slags, settler slags, ores, chrome bricks, copper bullion, coal and coke. There is nothing novel about any of the methods used, but it is always of interest to note the practice at different plants. Many chemists will differ with the author in some of his methods. Both electrolytic and permanganate-sulphocyanate methods are used for copper, practically as devised by Guess. The use of the chromate method for lead is interesting in view of the attempt of Western chemists to work out a satisfactory method along this line. Fusion methods are used for arsenic and antimony.

#### Lead.

**Bismuth Lead Smelting.**—Data on the blast-furnace smelting of bismuth ore are rather meagre, and consequently any information on the subject is of interest. A record of the results obtained in a 26-day run on a mixture of lead and bismuth ores is communicated to the *Eng. and Min. Jour.* for

April 9, 1910, by S. E. BRETHERTON. The Bismuth King Mine in Sinaloa, Mexico, produced a bismuth ore of the following composition: Bismuth, 2 per cent; iron, 33 per cent; silica, 31 per cent; alumina, 12.5 per cent; magnesia, 2 per cent; zinc, 1 per cent; copper, 9 per cent, and a trace of lime, arsenic and sulphur. The principal value is gold, and there is some silver. The lead ore produced carried: Lead, 50.7 per cent; copper, 1.4 per cent; zinc, 8.4 per cent; sulphur, 18 per cent; iron, 6 per cent; silica, 11 per cent, and alumina, 1 per cent. At the time the author made the test under consideration, there was also on hand from a previous campaign some lead bullion containing no bismuth and some silver. The furnace was 30 x 60 in. at the tuyeres and 14 ft. 10 in. from crucible to feed floor. A forehearth was improvised from an abandoned boiler. The first charge used carried 9.75 per cent lead and 1 per cent bismuth. The slag from this charge assayed 1.2 per cent lead and 1.1 oz. silver, with bismuth and gold present in quantities too small to estimate. This indicated a good saving of all the metals, so in order to curtail the lead ore and enrich the bullion in bismuth and gold, the amount of lead on the charge was reduced one-half, and the bullion was fed back into the furnace until it assayed over 17 per cent bismuth. About this time the bismuth losses began to rise, no doubt due to insufficient lead in the charge. Increasing the lead increased the saving. As soon as this feature was demonstrated it was decided to install a cupel furnace in order to secure the following advantages: (1) Freight and treatment saved by shipping richer bullion. (2) Less burden to be smelted in the furnace to get the necessary lead. (3) Litharge from the cupel furnace mixes well with the blast furnace charge, and (4) enables the metallurgist to carry a higher percentage of lead in the charge where lead ore is limited. In the cupeling process, bismuth is concentrated with the silver up to a certain point, say 50 to 60 per cent silver, when it begins to go off with the litharge. The author concludes that 80 per cent of the bismuth contained in a 2 per cent ore can be recovered by lead smelting in the blast furnace by using not less than 10 per cent lead in the charge and suitable dust chamber and bag house connections. The author also refers to his experiences with the use of green hardwood instead of coke for blast furnace fuel. He believes that green hardwood aided by the hot blast should be effective in copper matte smelting on a small scale.

#### Miscellaneous.

**Thoulet Solution in Ore Testing.**—The use of the Thoulet heavy solution is described in *Mines and Minerals* for April, 1910, by Mr. HENRY B. HALLOWELL. This solution is made by dissolving four parts of weight of potassium iodide in six parts of warm water and then adding five parts of mercuric iodide, stirring constantly. Evaporate until a slight crystalline scum forms on the surface and then filter. The clear solution has a specific gravity of about 3.2 and may be brought to any desired degree of dilution with distilled water. The author uses the solution for separating constituents of sand mixtures, crushed ore, jig middlings, etc., using an ordinary separatory funnel. He finds that valuable information can be obtained by this simple means, such as the character of middlings and tailings in concentrators, the control of jig middlings, where re-grinding is practiced and where the free gangue must be kept as low as possible, and in the estimation of percentages of mineral in an ore.

**Matte Refining.**—On account of the presence of some galena in the concentrates at the cyanide plant of the Mono Mining Company, Yreka, Cal., the zinc box precipitates contain considerable lead, which forms a matte in the process of melting the precipitates. In the *Pacific Miner* for March, 1910, Mr. J. E. COLLIE describes the method used to recover gold and silver from this very rich lead matte. The matte is broken into coarse pieces and melted with scrap iron. Metallic lead, carrying the gold and silver, is precipitated, and a barren iron matte is formed. The amount of iron used is calculated, assuming the



lead matte to be pure PbS and the resulting iron products to be FeS. Two-thirds of the necessary quantity is added as nails and small scrap, and when this is consumed, long iron spikes are added in the same manner as nails are used in assaying sulphide ores in the crucible.

## RECENT METALLURGICAL AND CHEMICAL PATENTS

### Gold and Silver.

**Filters.**—Modifications of the well-known Moore process of vacuum filtration of fine pulp have been made the subjects of letters patent granted to Mr. GEORGE MOORE, of Salt Lake City. The principal change from the present system of immersing the filter leaves successively into pulp, barren solution, and wash water, consists in having the filters enclosed in a pressure tank into which pulp, barren solution, and wash water may be successively forced by gravity pressure. The vacuum may be applied to the tank to aid in filtration or the plant may be so arranged that gravity pressure alone will be used to effect the

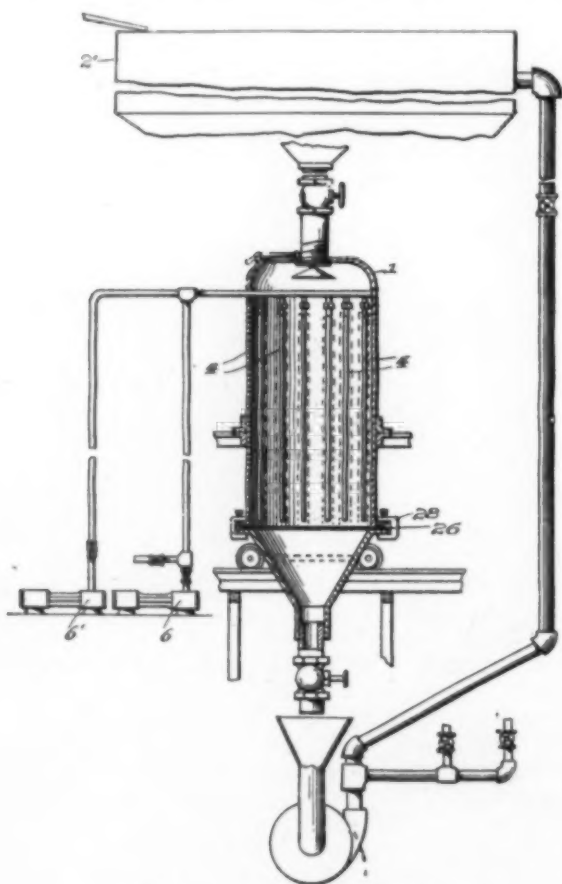


FIG. 1.—PRESSURE TANK SYSTEM.

filtration and subsequent washing of the cake. Two different modifications of the pressure-tank system are shown in the accompanying illustrations. Fig. 1 shows a vertical pressure tank (1) connected with a source of pulp supply (2) and with vacuum and pressure pumps (6 and 6'). Within the tank are filters (4) in the form of leaves or pipes so disposed as to give the maximum filtering surface. The bottom of the pressure tank is a conical member which is clamped to the pressure tank at 26 by a clamp 28. The conical bottom is on wheels and can be removed from the position shown. In operation pulp is admitted to the top of the tank and filtration commences at once. Uniformity in distributing is effected by the spreader 3. Filtration is allowed to continue until a suffi-

ciently thick cake forms, as indicated by the dotted lines outside the filter leaves. The vacuum pump is then placed in operation, and the balance of the unfiltered pulp withdrawn from the conical bottom. Barren solution and wash water are then successively applied in the same manner. When the cake is to be discharged, the conical bottom of the tank is unclamped, wheeled out of position, and the vacuum is then released and the cake allowed to fall of its own weight or by the assistance of air pressure if needed.

Fig. 2 represents the application of the same idea in another form. In this case the pressure tank is stationary and the head with the filter is removable for discharge to the position shown

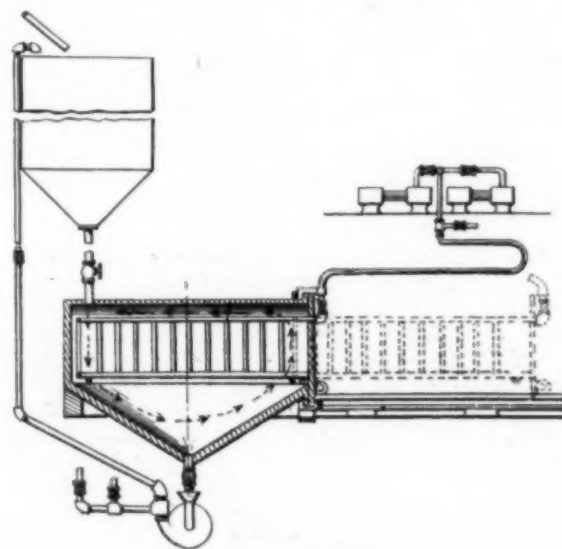


FIG. 2.—MODIFICATION OF FIG. 1.

by the dotted lines. It will also be noticed that the pulp in coming into the chamber will take the direction indicated by the arrows, thus maintaining the particles in uniform suspension during filtration. In still another form, not illustrated, provision is made for moving the tank away from the filter, which is stationary. (955,660-955,836, April 19, 1910.)

**Improvements in the Cyanide Process.**—To increase the efficiency and extend the scope of the cyanide process for gold and silver extraction is the object of certain methods of chemical procedure recently patented by Mr. JOHN COLLINS CLANCY, of New York. The invention is claimed to be unusually efficacious in the case of sulphide or other ores which have hitherto required roasting preliminary to cyanidation. The inventor claims that by the use of his methods this preliminary roasting will not be necessary. In addition to the use of potassium cyanide, Mr. Clancy uses potassium iodide and some strong oxidizing agent such as ammonium persulphate, ozone, or nitrogen peroxide. The effect is to form a cyanogen-iodine compound to dissolve the precious metals, the iodine being regenerated for use by the oxidizing agent used. The following proportions are said to be advantageous: 1 lb. potassium cyanide, ½ lb. potassium iodide, 3 lb. sodium persulphate, and ½ lb. lime, dissolved in 2000 lb. of water and used in the proportion of two parts of solution to one part of ore. If ozone is used, the quantity necessary must be determined in each case, but a proportion equivalent to 200 grams of ozone to 2000 lb. of solution may be used to advantage. The solution must be kept up the proper strength in cyanide and oxidizing agent, but the only additional iodide added is that required to compensate for ordinary mechanical losses. (955,318-9, April 19, 1910.)

**Continuous Vacuum Filtration.**—The latest suggestion for the continuous filtration of slimes is found in a machine recently patented by CYRUS ROBINSON, Mount Vernon, N. Y.

Briefly it consists of cylinders revolving in tanks of pulp and carrying over their surface a traveling belt filter medium, which acquires a thin coating of slime as it passes through the pulp tank and delivers a clean solution for precipitations. More specific description can be given by referring to the accompanying figures. Fig. 3 is a sectional elevation of the apparatus, in which 1 is a tank containing the slimes solution and 2 a tank containing water for washing the slime cake formed on the traveling filter. The drums 3 and 4 have a peculiar peripheral construction best shown in Fig. 4. Perforated wooden blocks 11 are fastened to the drum so that there are recesses 12 on the under side. Pipes 13 communicate with these recesses and with a valve chamber 14 which contains a stationary valve 15. It will be seen that this valve communicates with only that part of the traveling filter which is submerged in the pulp, and that as the drum revolves around the stationary valve, progressive communication is established by the pipes 13 between the chambers 12 and the valve port. If the valve chamber is then in connection with a vacuum pump, the solution from the tank will filter into this chamber, while a slime cake will be deposited on the traveling filter 7. The traveling filter has chain sprockets 8 on its edges which engage with the sprocket wheels on the edges of the drums. Provision is made to so adjust these sprocket wheels that the filter medium will always be tight and smooth.

The drum in tank 2 is similar to the one just described, except that there is a double valve whereby two successive washes may be applied to displace the solution held in the cake. The first wash would be strong enough to gold cyanide solution to be conducted to the precipitation boxes while the second wash would be weaker and could be used in such a manner as second best. The washed slime cake now travels, as indicated in the diagram, to a point where it is scraped off the filter by a brush 23, or other means so that the filter medium is again ready to receive another cake. In this manner the inventor seeks to continuously filter and wash a slime solution in a rapid and efficient manner. Suitable means of agitation are, of course, employed in the first tank. (954,466, April 12, 1910.)

**Arsenical Ores.**—Since the discovery of the Timiskaming district of Canada, metallurgists have given considerable attention to the metallurgy of the arsenical ores which have been

per cent. A patent has been granted to FREDERIC P. DEWEY, Washington, D. C., for a process especially designed to roast these ores without loss of silver. In the ordinary roasting process comparatively little arsenic acid ( $\text{As}_2\text{O}_5$ ) is formed and but little attempt has been made to produce a large amount of arsenic acid in the roast. It is the object of the inventor's process to produce as much arsenic acid as possible and to avoid as far as possible the production of arsenious acid. The essential element of the process consists in maintaining a very low temperature during the roast. Arsenic begins to oxidize considerably below the melting point of lead and when this

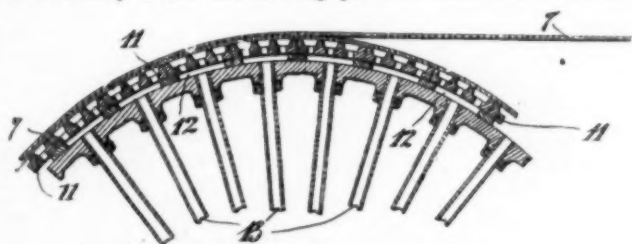


FIG. 4.—DRUM CONSTRUCTION.

oxidation sets in there is great danger of its developing too much heat for the successful conduct of the operation and it may be necessary to reduce the external heat in order to prevent the too rapid rise in temperature. The inventor gives a record of an experimental roast of an ore carrying 2700 ounces of silver, 58 per cent arsenic, 11 per cent cobalt and 4 per cent nickel. Starting with a cold furnace and a low gas flame arsenious acid began to come off in 17 minutes; in about an hour lead melted near the back of the charge and red spots began to appear in the ore. In order to keep the temperature down at this stage of the process the ore was stirred vigorously. At the end of about an hour and a quarter, the charge was very red and in another three-quarters of an hour the process was completed and the charge removed. At the close of the roast the heat was just high enough to cause zinc to thoroughly melt in front of the charge. By this process there was practically no loss of silver by volatilization, the assays showing a loss of less than 1 ounce per ton. On treating the roasted ore with sulphuric acid the arsenates and other compounds pass into solution, leaving the silver with the residue, which is practically free from cobalt and nickel, and can be recovered by various ordinary means. (954,263, April 5, 1910.)

#### Iron and Steel.

**Purifying Steel.**—A new process of manipulating steel in a basic open-hearth furnace is patented by Mr. REGINALD H. BULLEY (assigned to the Halcomb Steel Company, of Syracuse). The process consists essentially in pouring out the

entire contents of the furnace, particularly all the slag, depositing carbon in the furnace to produce the desired degree of carburizing, and then teeming back into the furnace the molten metal, care being taken to prevent the return of any of the slag. New slag-making materials may then be added where necessary further to purify the metal. By this process a continuous bath of metal is maintained in the furnace, which is both kept at the lowest point in phosphorus and sulphur, and recarburized to any desired extent. The great difficulties and disadvantages of the old processes are overcome or avoided, particularly the danger of the metal getting into a super-oxidized condition, with the attendant waste and difficulty of working; the tendency of the phosphorus to return from the slag into the metal; the difficulty of introducing carbon or

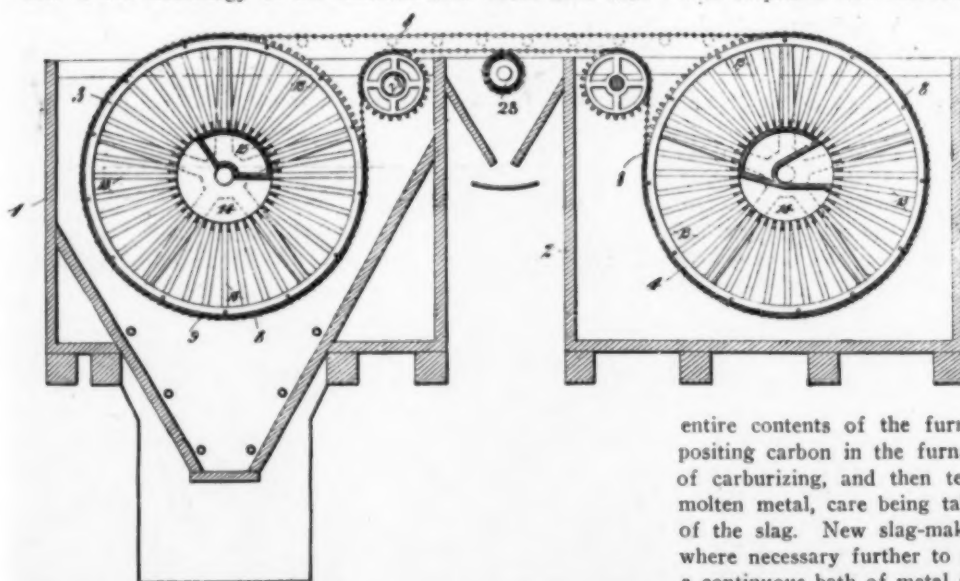


FIG. 3.—APPARATUS FOR CONTINUOUS FILTRATION OF SLIMES.

developed there. It is well known that when the silver ores carrying arsenic are roasted in the ordinary manner there is a heavy loss of silver due to volatilization with the arsenious acid ( $\text{As}_2\text{O}_3$ ) produced in the roasting process and that this loss is especially heavy when the arsenic content is as high as 50 or 60



carbon compounds (carburizing materials) through the slag.

This process is stated to be particularly valuable where an open-hearth furnace is used in connection with an electric furnace; a continuous bath may be maintained in the open-hearth furnace and the electric furnace supplied at frequent intervals with comparatively small amounts of molten metal (of high carbon if desired). The open-hearth furnace is essentially an oxidizing furnace, where it is difficult to maintain a bath containing a high degree of carbon for any length of time and there is danger of the metal getting into what is known as the superoxidized condition. In that condition the carbon is, practically, entirely removed and an excess of oxygen is present; while a metal very low in phosphorus can be obtained in that superoxidized condition (for transfer to an electric furnace), yet there are certain serious objections thereto. The superoxidized metal becomes of a creamy, semi-viscous consistency, so that it is difficult to work and very difficult to teem out of the bottom of the ladle by means of the usual stopper and nozzle, which is desirable, to avoid the return of any slag; there is considerable loss occasioned by a portion of the metal adhering to the sides of the ladle. Another serious objection to the use of metal in this condition in the open-hearth furnace is the great loss, for a considerable portion of the metal oxidizes and passes into the slag. Also when the metal in the open-hearth furnace has reached this superoxidized condition it is very difficult, by the ordinary process, to recarburize the bath.

With Mr. Bulley's new process the transfer of the purified metal from the open-hearth into the electric furnace is easy, since the metal can readily be teemed out of a ladle by the use of the stopper and nozzle in the ordinary way, and by taking over in the ladle a greater quantity than is needed and stopping the teeming operation when the desired quantity is in the electric furnace, no slag will be introduced into the electric furnace. This is very important, because, if any slag is introduced into the electric furnace, any phosphorus in said slag will pass into the metal in that furnace. The excess steel remaining in the ladle can then be returned to the open-hearth furnace and the loss of metal in the operation is very slight. (955,378, April 19, 1910.)

#### Electric Furnaces.

**Induction Furnace.**—Messrs. E. A. A. GRÖNWALL, A. R. LINDELAD and O. STALHANE, of Ludvika, Sweden, patent the construction of an induction furnace shown in Fig. 5. 1 is the transformer core, 3 is the primary coil, and 4 the crucible or furnace groove, which is provided with a comparatively long projection. The following advantages are claimed for this arrangement: The smelter bath can be placed as near to the iron core as with regard to the heat, from a technical point of view, is possible without any risk of damage to the insulation of the primary coil. Further, the space through which the leaking lines of force can unite can be reduced to the least imaginable, as the primary coil and that part of the smelting bath that lies around the iron core receive diameters of about the same size. (953,030, March 29, 1910.)

Another similar design of the same inventors is shown in Fig. 6, which shows the connection of the induction furnace with a blast furnace. The material heated and reduced in the blast furnace drops in molten state directly into the secondary channel 5 of the induction furnace. 4 is the primary coil and 3 is the transformer coil. (953,029, March 29, 1910.)

**Resistor Material.**—The following resistor material for rheostats and the like is patented by Mr. JOHN T. H. DEMPSTER, of the General Electric Company: 91.6 per cent iron, 2 tellurium, 6 silicon, and 0.4 manganese. This alloy is relatively cheap and has a sufficient resistance for use in rheostats and the like. It has high tensile strength and can be rolled and drawn without difficulty. (953,412, March 29, 1910.)

**Cover for Electric Furnace.**—To protect the outer portions of electric-furnace electrodes against destruction by the

hot furnace gases, Mr. PAUL GIROD, of Uguine, France, constructs the cover of the furnace as follows: The cover is formed of a metal ring, seated in refractory bricks and supporting one or more inner pieces of cast iron, which give passage to one or more electrodes, insulating refractory bricks

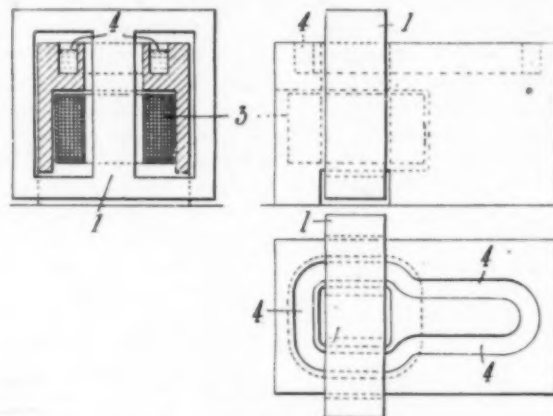


FIG. 5.—INDUCTION FURNACE.

being interposed between the iron pieces and the ring. When the electrodes are not of the same polarity the metal pieces, through which they pass, are independent of each other and insulated from each other by masonry. The electrodes are accurately fitted at their passage through the cast iron, so that the hot air and gases cannot pass through the electrode holes; for the exit of the gases special outlet holes are provided. In order to avoid fusion of the cast iron it is cooled by water circulation. But to prevent any danger of an explosion in case of a breakdown of the cast iron, the cooling water is passed

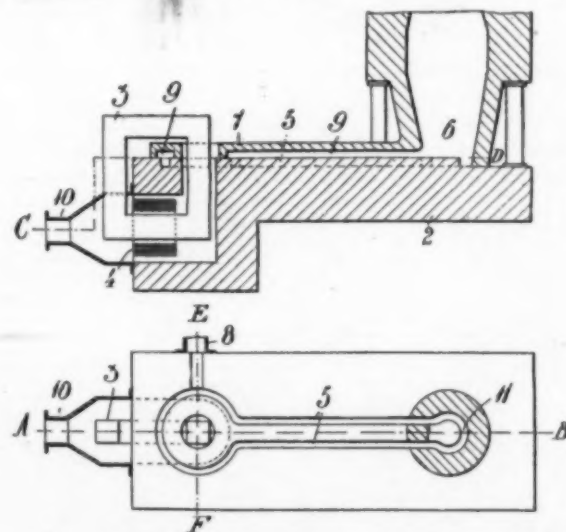


FIG. 6.—COMBINATION OF INDUCTION FURNACE WITH BLAST FURNACE.

through pipes which are mechanically independent of the cast iron. To make such a cover iron pipes are placed in a mold and iron is cast around the pipes, which then form a portion of the water circulation. Even should the cast iron burst, the pipes remain intact. (956,699, May 3, 1910.)

**Furnace Construction.**—A patent of Mr. Alois Helfenstein, of Vienna, Austria, relates to the furnace construction described and illustrated on page 46 of our January issue. The first claim refers to a "dome mounted over the furnace chamber, said dome carrying the electrode suspended into said furnace chamber, and means to prevent the escape of gases from said furnace, and a cone at the lower end of said dome." (949,895, Feb. 22, 1910.)

**Electroplating.**

**Production of Conductive Layers on Ceramic Wares.**—According to Mr. S. HELLER, of Teplitz, Austria, a conductive layer on ceramic wares (suitable for subsequent electrodeposition) is produced from a mixture of a solution of celluloid in an alcohol with tar, unsaturated hydrocarbons and gold-graphite. The mixture is applied to the ware and is burned in it in a muffle at a temperature of about 200° C. The gold-graphite is made by changing 3 grams of pure metallic gold to gold-protochloride, adding 500 grams of water and 10 grams of potassium cyanide, mixing this solution with 1 kg of chemically pure graphite, and burning the mixture in a muffle furnace at a temperature of 600° C. A mixture of 5 parts by weight of unsaturated hydrocarbons and 12 parts by weight of gold-graphite finely ground together in a color-grinding machine is particularly suitable. The layer formed is a good conductor and firmly adherent. (952,901, March 22, 1910.)

**Plating Steel Tubes.**—Mr. WILLIAM H. WINSLOW, of Chicago, Ill., patents a method of electric steel tubes, especially for small boilers (like automobile boilers), in order to produce tubes strong enough to stand the torsional strains and at the same time so thoroughly protected by the plating as not to be subject to corrosion. Copper is a particularly effective coating against corrosion. The resulting tube is practically a double tube, a steel tube surrounded by a copper tube, the two being practically one piece. The ends of the steel tubes are first closed by plugs of wood or other non-conducting material; conductors lead through the centers of the tubes and are bent within the tube. The tubes are then subjected to sand-blasting and then dipped into a dilute solution of copper sulphate, whereby a thin film of copper is deposited on the steel surface. The tubes are then electroplated in an alkaline plating solution. (The conductors through the end plugs forming the electric connection with the steel tubes, which are the cathode.) The electroplating is finally continued and concluded in an acid plating bath. (950,777, March 1, 1910.)

**Wire-Plating Machine.**—The plating of continuous lengths of such material as chain and barb wire offers some difficulties which Mr. GEORGE L. WALLACE, of Bridgeport, Conn., seeks to overcome in a machine which he has recently patented. It comprises a series of tanks, cleaners and polishers, through which several continuous lengths of material of the class mentioned can be automatically passed for plating. The metal is fed successively through a sand blast, a electro-cleaner tank, rinsing solution, plating solution, polishing apparatus and winding drums. All parts of a strip chain or barb wire are thus plated so that no ends or edges are left exposed to the action of the elements which would set up a galvanic action at those points, causing rapid deterioration. (954,833, April 12, 1910.)

**Miscellaneous.**

**Down-Draft Furnaces.**—With a view to economy in the process of smelting ores of copper and other metals, BERNARD DE ST. SEINE, of Paris, has patented a down-draft furnace with a single row of twyers placed above the smelting zone. The blast passes into the charge of mixed ore and fuel and the gases and the molten products issue below. This manner of operation is supposed to prevent the formation of undesirable deposits inside the furnace and to avoid the dust losses which ordinarily occur in an up-draft furnace. It is claimed, further, that hotter slags are obtained from which a separation of copper matte and such products can be more readily effected. Any form of solid fuel can be efficiently employed. (952,284, March 15, 1910.)

**Hard Copper Alloy.**—Messrs. JAMES NAULTY and JOHN SCANLIN, of Philadelphia, produce a copper-chromium alloy which is "approximately as hard as steel, thereby permitting edged tools to be made therefrom and adapting the metal for rolling hot or cold, welding and forge work." The copper and chromium are mixed in the proportion of nine to one. An alloy consisting of 45 per cent copper, 5 chromium and 50

zinc is also mentioned in the patent. (959,156, May 24, 1910.)

**Copper Alloys.**—To produce tungstate of copper, Mr. GIDEON BOERICKE, of Philadelphia, Pa., lets sodium tungstate react with copper sulphate, forming sodium sulphate and a precipitate of tungstate of copper. In an analogous way chromate of copper is produced by the reaction between sodium chromate and copper sulphate, etc. (959,048, May 24, 1910.)

**Reduction of Refractory Ores.**—For the reduction of refractory ores, particularly oxides and sulphides, Mr. GIDEON BOERICKE, of Philadelphia, Pa., proceeds as follows: He takes a quantity of the refractory oxide to be reduced and places with it some manganese compound, as, for example, ferromanganese, together with another metallic reducing agent, such, for example, as ferrosilicon—the said other reducing agent referred to being of such a character that the two reducing agents together in their oxidized form will serve the purpose of a flux. In some cases he adds carbon. The mixture is subjected to heat. (958,851, May 24, 1910.)

**Graphic Recorder for Cooling Curves.**

BY C. B. THWING, PH.D.

There are various methods in use for studying the transformations in materials in which heat is absorbed or liberated at various stages of the heating or cooling process. The instrument about to be described was designed especially for studying the cooling curves of iron and iron alloys. It can be modified in various details to make it more suitable for special problems.

The method consists in comparing the rate of cooling of an adjacent neutral body which may be assumed to follow the changes of temperature of the furnace quite closely. The instrument consists of two galvanometers mounted side by side, and recording on a single chart, which is carried forward by one clock. The needles are simultaneously depressed on the chart once in 10 seconds. The chart has two or more speeds, as may be desired.

One galvanometer is attached to a thermo-couple imbedded in close contact with the metal of the neutral body. The other galvanometer measures the e.m.f. of a series of short thermo-couples, one set of the junctions of which is imbedded in the neutral body; the other set of junctions similarly imbedded in the test piece.

Fig. 1 shows the thermo-couple in position for test. The

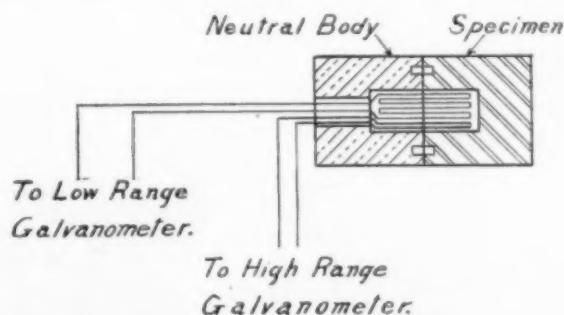


FIG. 1.—ARRANGEMENT OF THERMO-COUPLES.

size of the test piece need not exceed 1 in. in length and the same in diameter, with a cavity  $\frac{3}{4}$  in. in diameter and  $\frac{1}{2}$  in. deep. The galvanometers are sufficiently sensitive so that the one measuring the temperature of the test piece may be made to give full deflection for a range of a few hundred degrees only, while the galvanometer attached to the differential couple will give the full scale deflection for a difference of 20° below 400°, and for a difference of 15° between 400° and 1000° with three thermo-couples in series.

The specimen cooling curve shown in Fig. 2 was made with a specimen of tool steel as the test piece and copper as the neutral body. By placing resistance in series with the



galvanometer the sensibility may be reduced when the temperature differences are so large as to make it necessary. The

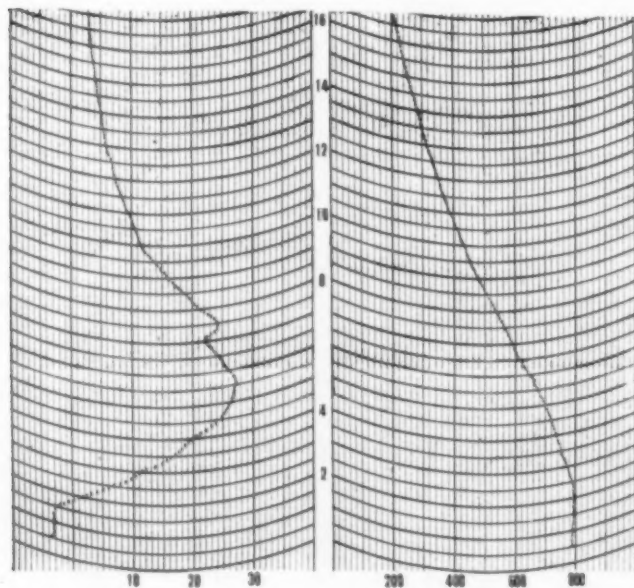


FIG. 2.—SPECIMEN COOLING CURVE.

zero of the galvanometer may be easily set to any part of the scale for convenience in taking heating or cooling curves, as may be desired.

#### A New Electric Steel Furnace Plant.

The Simonds Manufacturing Company, of Fitchburg, Mass., with branch factories at Chicago, Ill., and Montreal, Canada, makers of the well-known "Simonds" line of saws and machine knives, are installing in the crucible-steel department of their Chicago plant a Girod electric furnace.

The experimental plant of the Simonds Manufacturing Company is of special interest just at this time, as they have just acquired a tract of 60 odd acres of land at Lockport, N. Y., with excellent railroad and canal connections and ample electric power from Niagara Falls, which will make desirable and practical the melting of at least a portion of their steel by electric furnaces, should the rather rigid requirements of their quality be met by the electric process and furnace.

It is not the intention of the Simonds Manufacturing Company to do much, if any, refining of their higher grades of steel, but to employ the same raw materials, consisting largely of the best brands of Swedish melting bar, which they are now using, and are expecting their success in the application of electric melting to be entirely on the lines of uniform product, elimination of crucible troubles, etc., and a reduction in labor costs.

The new steel works at Lockport represent an increased investment of \$250,000 to \$300,000, not including their present very complete equipment, and the production from this new mill will be from two and one-half to three times the capacity of the present mill at Chicago. Provision is being made at Lockport for the installing of more electric furnaces of a larger size than the one which they are now installing, should the expectations of the company in the success of the experimental Girod furnace be realized. This will probably be the first Girod electric furnace to be operated in the United States.

#### Pyrometer Laboratory.

At the recent Pittsburgh convention of the American Electrochemical Society numerous members used the opportunity to visit the laboratory of Mr. S. H. Stupakoff, which is par-

ticularly well equipped for the commercial testing of pyrometers and electrical measuring instruments.

One section of the laboratory is devoted especially to pyrometer work and the principal types of thermoelectric, resistance, and radiation instruments of 10 or more well-known manufacturers may be seen in operation. Another portion of the equipment is adapted for adjustment and repair of electrical measuring instruments for commercial and laboratory service.

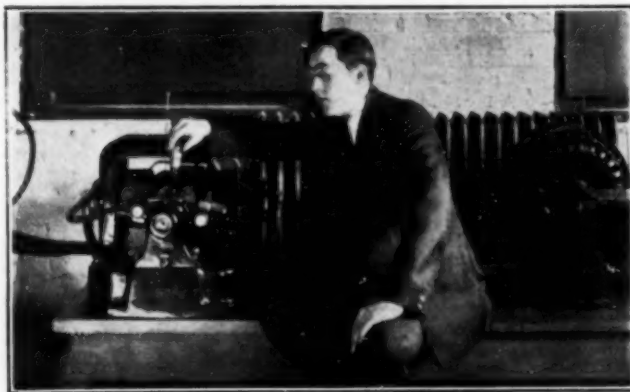


FIG. 1.—MOTOR-GENERATOR SET.

The sections for different classes of work are each centered about a table, and might be divided as follows:

Power supply, thermoelectric testing table, Fery radiation pyrometer, recording and indicating instruments, protection tubes, ammeter testing set, voltmeter table and potentiometer table.

Electric power is supplied from the mains of the Allegheny County Light Company at 220 volts single-phase and two-phase and direct current from the building power station at 110 volts.



FIG. 2.—THERMO-ELECTRIC TESTING TABLE.

Motor-generator sets in the laboratory furnish direct current of high intensity at low voltage, and small voltage transformers step the alternating-current voltage down to 110 volts and up to 660 volts. One of the motor-generator sets is shown in Fig. 1. A Zucker & Levett & Loeb generator gives 10 amp to 720 amp at 6 volts and is belt driven by a 3-hp Westinghouse single-phase motor. Current for this is taken at 110 volts from the 220-volt line through a small transformer.

Another table with motor-generator set supplies direct cur-

rents at varying voltages from 0 to 500 for the voltmeter testing outfit.

Fig. 2 shows the thermoelectric testing table. Above is a switchboard with three electric furnaces on front and one at top on the right-hand side. Two thermocouples can be seen inserted in the middle furnace. They are connected on the table to a Siemens & Halske precision galvanometer on the left and in the center to a Robert Paul duplex indication, which is provided with three scales, namely, a millivolt scale, one

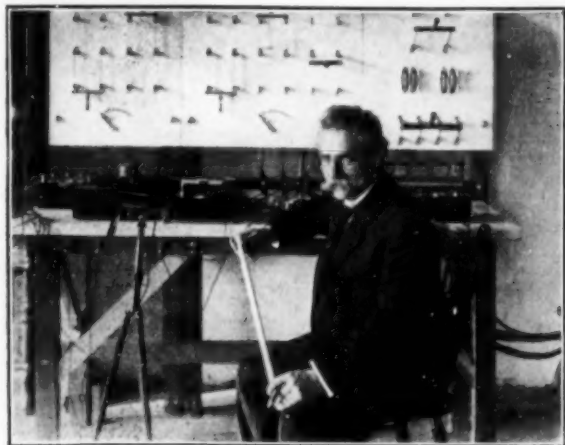


FIG. 3.—FERY RADIATION PYROMETER.

temperature scale for platinum-rhodium thermo-couple, and one for base-metal couples. To the right stands a Meylan-D'Arsonval suspension galvanometer used in connection with the Fery pyrometer.

This arrangement is used to compare the needle deflections of instruments on test with the precision standard. The S. & H. galvanometer, which is of the suspension type, is mostly used as the standard of comparison. It is at frequent intervals checked by potentiometer.

At the lower portion of the marble switchboard are three

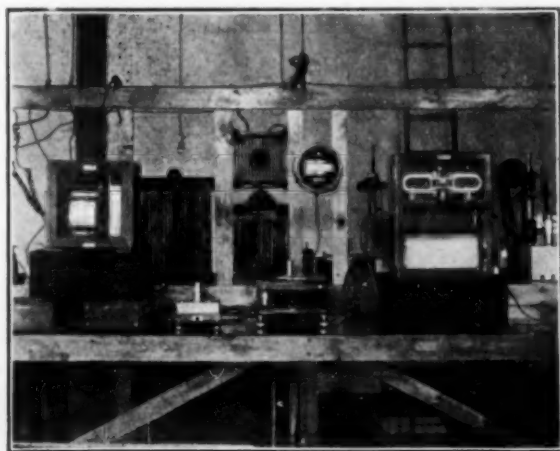


FIG. 4.—INDICATING AND RECORDING INSTRUMENTS.

sets of contacts, of which the one to the left is connected to an electric furnace in series with suitable resistance. This enables either one of the furnaces to be heated to any degree of temperature up to about 2500° Fahr. by shifting the center contact to its respective terminal. The lower, small tubular furnace, however, is used only at exceedingly low temperatures, never above 200°-250° Fahr. It carries in its interior a large number of thermo-couples connected up in series to the switchpoints arranged in a circle at the right side of the board. With this combination it is possible to tap thermoelectric currents in 20 different steps from, say, 1 to 20 millivolts, varying

by 1 millivolt each, or any higher range up to perhaps 150 millivolts, in correspondingly larger steps.

This seems to be a very convenient way of commercially testing instruments of various makes.

To the extreme left one of three electric furnaces can be seen, which are mostly used for determining cooling curves, etc. The two larger furnaces are hidden behind Mr. George Schindler, who is in charge of the laboratory.

Just above his head hangs an experimental hot plate constructed of a high-resistance metallic ribbon. This apparatus is conveniently used for demonstrating the action of radiation pyrometers. In the condition as shown in the photograph it would give the radiation of a hot body in the open air. By placing it between two long muffles with both ends open a close approximation to black-body temperatures can be obtained. By this means it can be shown in an amazingly short space of time why radiation pyrometers should be used under conditions which approach as nearly as possible black-body conditions.

Most instruments of this nature are calibrated for black-body temperatures, and naturally their reading can be correct only when thus used. By simply removing the muffle mentioned and leaving the telescope of the pyrometer pointed to the heated plate an immediate drop of the indicator needle to 50 per cent or more can be observed. A simple explanation of this difference in the reading is that when a hot body is ex-

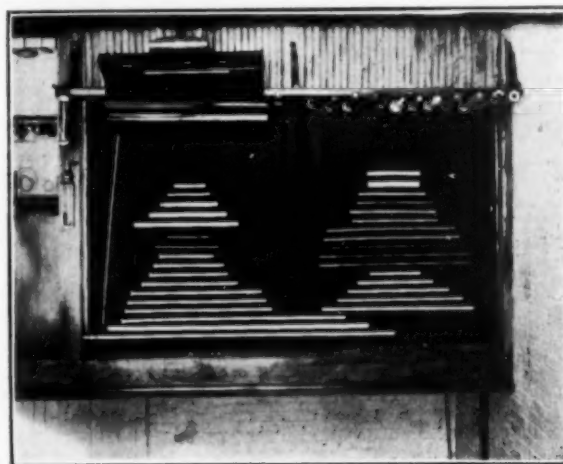


FIG. 5.—PROTECTION TUBES FOR PYROMETERS.

posed in the open air a portion of the heat which it radiates is lost into space and only a small portion of it can be collected by the mirror and concentrated upon the sensitive thermo-couple which forms the active portion of the instrument.

The telescope of the Fery radiation pyrometer mounted on its tripod is shown in Fig. 3. The radiation type of pyrometer has been designed for temperatures above those that can be measured by a thermoelectric couple on account of the deterioration of the latter at high temperatures. Base-metal couples are entirely reliable to about 1000 Fahr. and platinum-rhodium couples to about 3000° Fahr. Radiation pyrometers are suitable for any temperature up to the highest limit, but should preferably be used above red heat.

The gentleman seated at the table explaining the characteristics of the Marquardt-mass protection tube in his hand is Mr. S. S. Stupakoff, whose work as a consulting engineer on heat-measuring problems and apparatus has been well known for the past 15 years.

The Taylor Instrument Companies, of Rochester, N. Y., of which Mr. Stupakoff is the Pittsburgh representative, manufacture the Fery pyrometer, as well as the Foster fixed-focus pyrometer (which is described in detail elsewhere in this issue), and the standard line of "Tyco" thermoelectric pyrometers, of which a large selection is on exhibit in the laboratory. One



of the most commendable features of the exhibit is the arrangement which permits any one of the instruments to be shown in active operation on a few minutes' notice.

In Fig. 4 is shown a portion of the collection of various indicating and recording instruments. To the left, elevated, stands a thread recorder, and below two "Tycos" indicators, all made by the Taylor Instrument Companies, in Rochester, N. Y.

Immediately to the right is a Siemens & Halske precision galvanometer. Continuing, a S. & H. recording instrument, directly above a S. & H. wall-type pivoted galvanometer, and at the right side of the table a Leeds & Northrup recording instrument, which has been fully described in our columns.

Behind the latter instrument is to be seen a portion of a Whipple indicator. These last two instruments are exclusively used in connection with platinum-resistance pyrometers, as is also a Callender recording instrument, which is suspended on the wall to the right, but not shown in the cuts. The other instruments mentioned above are for use with electric pyrometers or radiation pyrometers.

Behind this table just described is a similar one extending the full length of the former shown in the cut, and at the extreme right hand of the same may be seen a Pellin thermoelectric recorder. Among several instruments upon this table,



FIG. 6.—AMMETER TESTING TABLE.

but not visible in the cut, are a selenarium, a number of various types of rare-metal and base-metal pyrometers and several Foster fixed-focus pyrometers.

While it is unnecessary to go here into a detailed description of the instruments it should be mentioned that all means were provided for testing them and seeing them in actual operation under conditions closely approximating those found in practice.

Fig. 5 shows the exhibit of protection tubes for the electric and resistance pyrometers, including the following types:

Marquardt-mass, Royal Berlin porcelain, electro-quartz, transparent silica, pure magnesia, nickel, and refractory fire-clays.

On the shelf are various types, lengths, and shapes of fire-clay, graphite and plumbago tubes and tips.

To the right below is a case containing a standard inspector's outfit Le Chatelier pyrometer, while above is a sample case of miscellaneous protection tubes.

A few of the superior class of Hohmann & Maurer "Tycos" industrial thermometers are fastened to the right of the black-board. Below this on the floor are some tubes of electro-quartz and refractory clays of exceptionally large size. One of these is used in connection with the Fery pyrometer to obtain true black-body radiation.

The sections of the laboratory devoted more particularly to testing of electrical measuring instruments, such as commer-

cial service wattmeters, stationary instruments and laboratory apparatus, are shown in the remaining views.

Fig. 6 is the ammeter testing table. The meter on the small table to the left is a Weston laboratory standard with seven shunts ranging from 1 amp for full-scale deflection to 1000 amp. One side of the line is so arranged that the plus sides of all shunts are on the busbar and the current goes through the overhead rack, which forms the adjustable "load." The

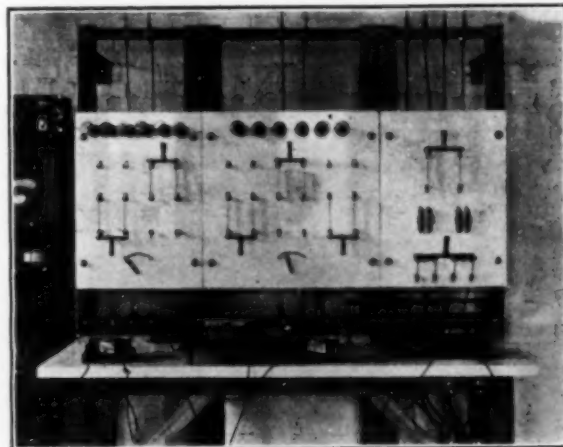


FIG. 7.—SWITCHBOARD OF VOLTMETER TABLE.

other sides terminate in a plug which can be inserted in the receptacles on the lower slab of the board for the necessary full-scale readings on the instrument when using any one of the shunts. The upper sets of receptacles serve to change the board from alternating current to direct current, or vice versa.

The small transformer under the table is a step-up from 5 amp to 100 amp. The two instruments on the table are undergoing repairs.

The switchboard of the voltmeter table, shown in Fig. 7, is so arranged that by using the circular switch with its contacts any voltage from 0 to 650 can be obtained, the finer graduations being secured by moving the sliding resistances seen on the table. The switching connections permit this voltage to be put upon the ammeter board when desired.

The second and fourth instruments on the table are Weston



FIG. 8.—POTENTIOMETER TABLE.

laboratory standard voltmeters, direct current and alternating current, respectively, while the two smaller meters are in for test and calibration. The 1-to-6 step-up "Pittsburgh" voltage transformer is shown under the table at the right.

In the cases to the left of the voltmeter table are a large number of various instruments, mostly for use in connection with pyrometric measurements. At the corner of the marble table is to be seen a portion of a "Chauvin & Arnoux" record-

ing instrument. Above is a thermoelectric battery giving about  $2\frac{1}{2}$  volts by simply lighting the Bunsen burner, which is a part of the apparatus. On the top shelf sets a Maloney thermopile and behind it a Hartmann & Braun voltmeter, while on top of the glass cases are some carrying cases containing inspectors' outfits of Mr. Stupakoff's make and design. The balance of the shelves of these cases carry a collection of interesting apparatus, among others a variety of platinum-wound electric furnace tubes. It might here be mentioned that all of the electric furnaces described above are platinum wound, some of the Heraeus type with platinum foil and others with platinum wire.

The potentiometer table with a Leeds & Northrup potentiometer and its resistance to the right are shown in Fig. 8. In the left foreground is a Kohlrausch bridge used for making resistance measurements. A Weston standard cell supplies the potential and a Leeds & Northrup D'Arsonval suspension reflecting galvanometer (rear view shown) completes the outfit. The meter to the right is on test.

The main switchboard is not shown. It has the line switches and fuses with the wattmeters for single and two-phase lines.

The laboratory, as at present described, is of comparatively recent date, and is even yet incomplete, several additional pyrometers and other instruments having been ordered, many of them from foreign lands.

### A New Gas Producer Design.

The development of gas producers has been in the direction of increasing the amount of coal gasified per unit of producing capacity, and the reduction of the labor required in operating. Various devices have been introduced to accomplish this, such as mechanical poking and stirring of the fuel bed from the top, and continuous and even distribution of the coal in feeding, but little attention has been paid to devices by means of which the descent of the fuel bed in the producer is regulated and controlled, and to devices by means of which ashes are removed from the ash bed upon which the fuel bed rests, automatically and regularly.

All of these devices are embodied in the design and operation of the Forter-Trump gas producer, shown in Figs. 1 and 2.

The novel features of this design are the means of feeding the coal and removing the ashes continuously. The coal feed is accomplished by using the Trump knife mounted on a table, each half of which is of spiral shape. The knife and water-cooled table revolve at different rates of speed, thus delivering the coal onto the fuel bed, uniformly from the center to the circumference. In this design, the feeding knife is of sufficient depth and strength to prevent any clogging of the feed in case a large lump finds its way into the hopper.

The ash removal is accomplished by a revolving deflector or Trump knife, so designed as to give a radial thrust to the ashes. In operation, the table is stationary, and the knife is slowly revolved, cutting a section of the ashes out from the ash bed under the fire, and dropping the whole bed of fuel and ashes in pie-shaped segments onto the table, thus repeatedly dropping the bed, regularly breaking up the whole mass of incandescent fuel, preventing caking of the fuel bed and the formation of openings or holes through the fuel bed during operation.

The knives are tapered; that is, the thickness of the knife at the toe is smaller, and is larger at the heel; the knives can be used either singly or doubly, and operate to sweep out from under the column of ashes and coal a uniform section of the ashes, which may be varied by the taper of the knife from toe to heel. The movement of the knife causes the column of ashes and coal above to drop down uniformly over the whole area, and thus keeps the whole bed of coal in movement,

leaving it porous and free from coke or cinder masses and without holes.

The fuel is fed continuously, and the ash knife may be run continuously at a slow speed of 20 or 40 minutes each hour; in this way, the fuel bed is kept level all around.

The air and steam necessary for gasification and partial combustion is delivered by two steam blowers into a circular wind box, which contains the Forter circumferential grates—these blowers are located on opposite sides of the box; a third steam blower delivers air and steam through a centrally located vertical tuyere with cone-shaped hood, to the center of the fuel bed. The Forter circumferential grate is inclined at a steep angle to the horizontal, thus allowing the incandescent fuel and the ashes to easily slide down on it.

A perfectly uniform distribution of air and steam over the whole area of the fuel bed can be effected by reason of this arrangement. The gas maker has the supply of air completely under his control, as he can force more or less air either to the center or circumference of the bosh, as the nature of the fuel or the condition of the gas may require.

The grate area is very large. As it does not depend on the inside dimensions of the producer, it can be made larger than on other producers which have the inlet of air only in the center. Access to the ash knife and table is easily obtained by doors placed conveniently on the shell, as shown on cut, Fig. 1, or by lifting the water-sealed shell, as shown in Fig. 2.

A 10-ft. producer of the Forter-Trump design will gasify 30 tons per day bituminous coal, nut size, and 25 tons per day of nut and pea coal mixed. With fine anthracite coal and with a 7-ft. diameter producer, the producer will gasify 7 tons of such coal per 24 hours.

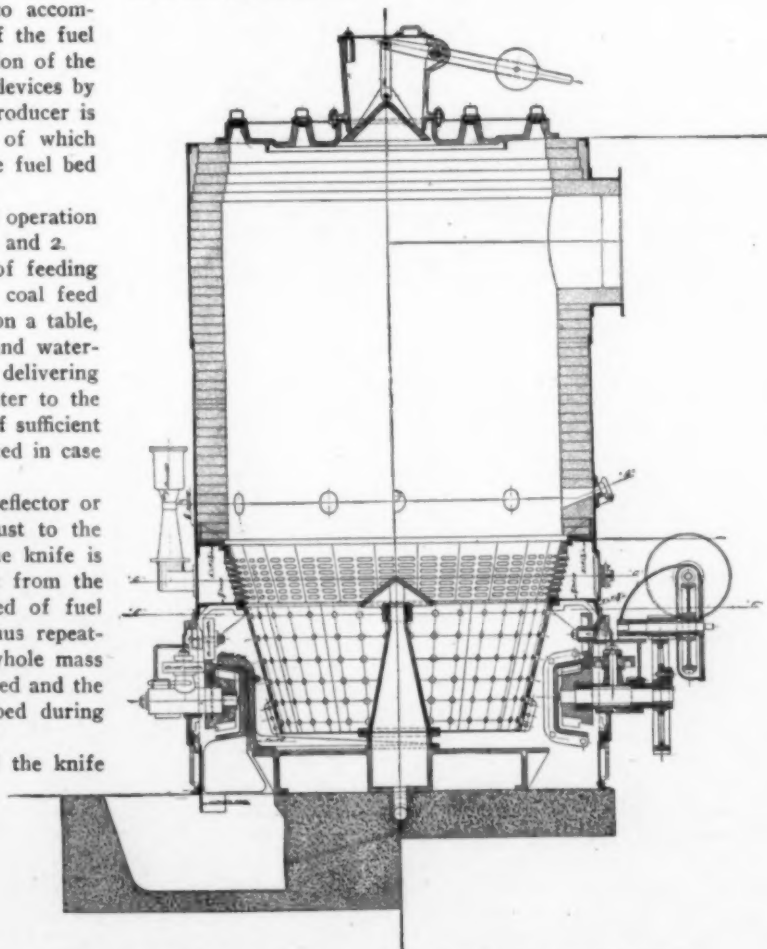


FIG. 13.—HAND-FED PRODUCER, WITH AUTOMATIC ASH EXTRACTOR. VERTICAL SECTION.



When the gas is used hot for metallurgical purposes, the calorific efficiency of the producer plant would be 85 per cent, and if the gas is cooled to 75° Fahr., or 80° Fahr., the efficiency would be 80 per cent. The high efficiency is due to continuous coal feed and removal of the ashes which is clearly demonstrated by the analysis of the ashes which for long periods show only 35 per cent carbon, and are always either red or white, depending upon the kind of fuel in use. Tests of averages of the ash for a week at a time, show in one case 3.21 per cent carbon, and in another case 3.5 per cent, which, with producers of any other type, run from 7 to 13 per cent.

On account of the continuous removal of the ashes and the constant feed, the gas produced by the Trump producer is very uniform in quality and under the control of the operator. The maximum volume is obtained from any given coal on account

Referring to the illustrations, Fig. 1 represents the Forter-Trump gas producer with ash pans, similar to the ordinary water-seal gas producer. The ash knife is attached to a cast-iron knife ring, geared on the inside. The knife ring is held in position by guide rolls on top, inside and the outside, and is placed above the table. The ashes are thrown off the table into a groove around the table, and from there are removed into the water-seal ash pans by two scoops attached to the revolving knife ring.

Fig. 2 represents the Forter-Trump producer with automatic feed, ash knife, ash hopper and water seal. The ash knife is attached to a knife ring with ball bearings below the table. The ashes are drawn off once a day into a bucket or suitable ash car. The shape of the ash knife is shown on the plans.

That this producer has passed the experimental stage is shown by the fact that several of them have been in use for over two years at two large industrial plants in this country. Its great advantages are to be found, as already stated, in the mechanical feed, which will handle any size of coal; and in the continuous removal of the ashes, which is accomplished by the Trump knife.

These producers are now being put on the market by the Forter-Miller Engineering Company, Hartje Building, Pittsburgh, Pa., who are prepared to contract for any size of installation required, and also contract for remodelling the ordinary water-seal gas producer.

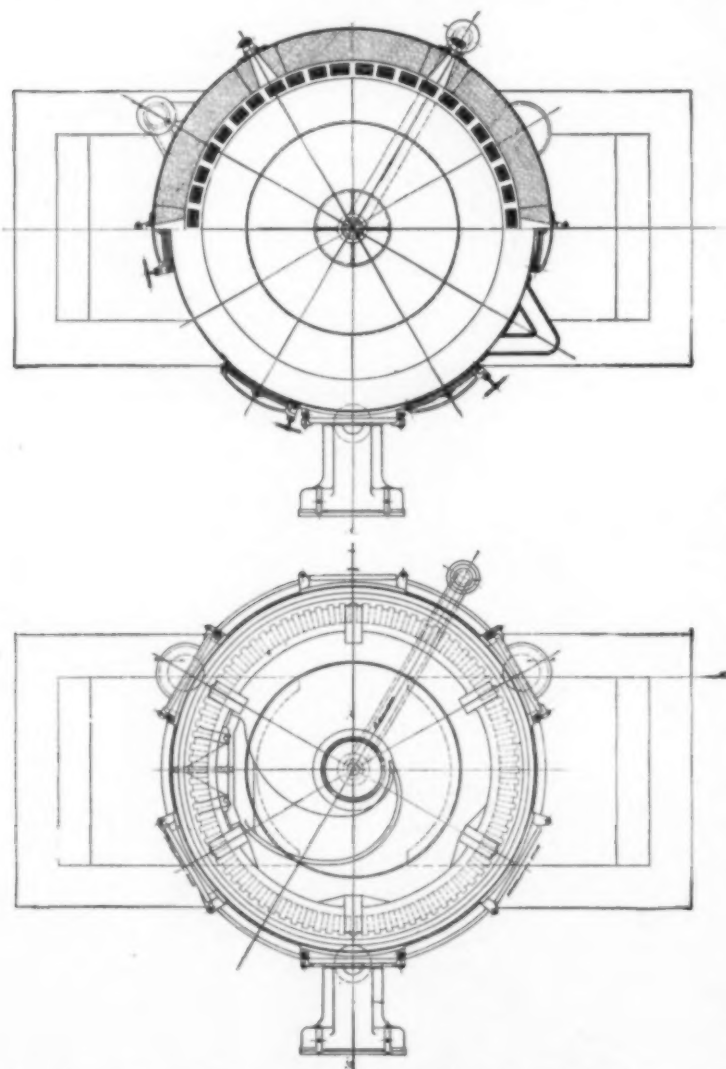


FIG. 1b.—HAND-FED PRODUCER, WITH AUTOMATIC ASH EXTRACTOR. CROSS-SECTION.

of the operation of the producer, which fact is evidenced by the low carbon in the ash.

Eight producers of this type require the services of one man to supervise the operation on top and one man to take care of the removal of the ashes. These, with a foreman on each turn complete the force, where coal is delivered mechanically into the feeding apparatus.

The power required to revolve the knife has been measured and found to be for one revolution in two hours 2 hp as the knife is usually run; when run continuously, at one revolution in six hours, the power would be cut down to less than 1 hp.

### Obituary.

Mr. Townsend Wolcott, for the past ten years the electrical inspector and electrical engineer at New York for the Signal Corps of the United States Army, died suddenly on April 29 of pneumonia, after an illness of but a few days. Mr. Wolcott, who was born in New York City on July 18, 1857, had won many sincere friends by his untiring activity for the best interests of his profession. Mr. Wolcott was an active member of the American Institute of Electrical Engineers, which he served in various capacities and by arduous committee work. He was a charter member of the American Electrochemical Society, and used to attend regularly the meetings of the New York section and to participate in the discussions. Aside from his engineering work, he was a mathematician and theoretical physicist of no mean ability. But his many friends will like to remember him best as a man of highest professional ideals.

Mr. Walter Craig Kerr, president of the Westinghouse, Church, Kerr & Company, died at Rochester, Minn., on May 8. He was born at St. Peter, Minn., on Nov. 8, 1858. He was an assistant professor at Cornell University until 1883, when he joined the Westinghouse Machine Company. In 1884 he became one of the organizers of the firm of Westinghouse, Church, Kerr & Company.

### Pittsburgh Section American Chemical Society.

For the next months the following program of papers has been arranged by the Pittsburgh Section of the American Chemical Society:

June 16, 1910.—"The Chemistry of the Clay Industries," A. V. Bleining, chief chemist, Ceramic Division, United States Geological Survey.

Sept. 15, 1910.—"Water-Softening Problems," J. C. W. Greth, chemist, W. B. Scaife & Sons Company.

Sept. 15, 1910.—"The Reduction of Iron by Carbon Monoxide," G. D. Chamberlain, chemist, Carnegie Steel Company.

Oct. 20, 1910.—"Steel Manufacture," Prof. F. W. Crabtree, Carnegie Technical Schools.

Oct. 20, 1910.—"Chemistry and Chemical Technology of the Industry," D. M. Buck, chemist, American Sheet & Tin Plate Company.

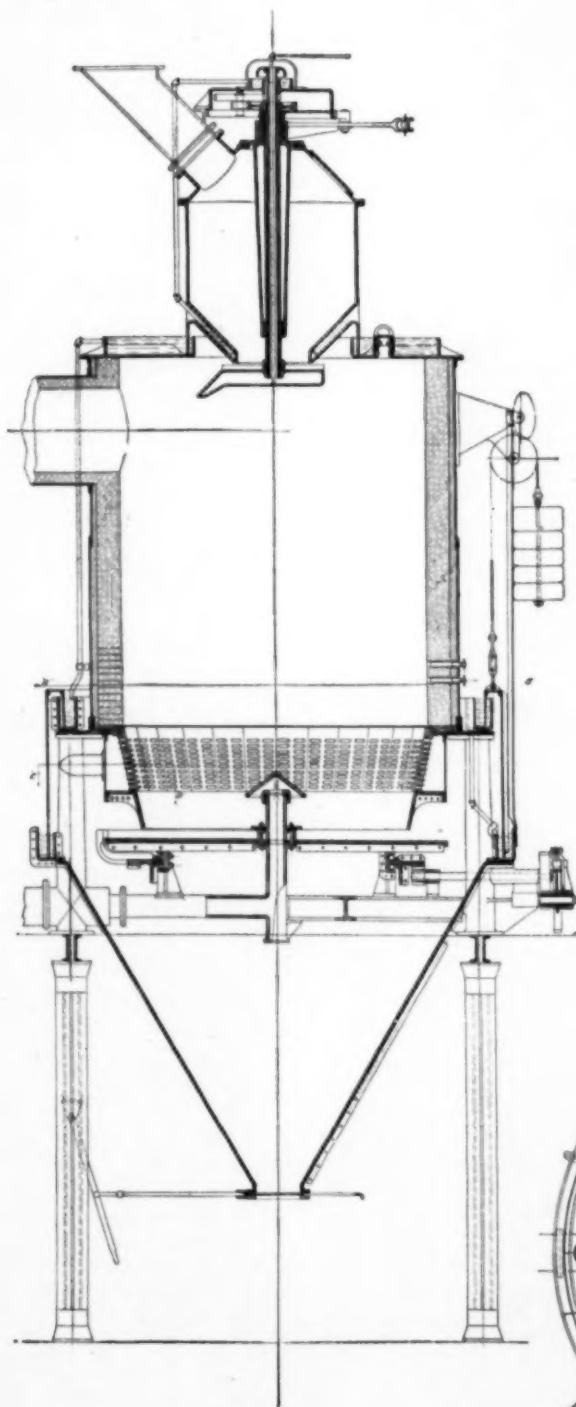


FIG. 2.—AUTOMATIC FEED, WITH AUTOMATIC ASH EXTRACTOR AND ASH HOPPER.

Nov. 17, 1910.—"The Analysis of Aluminium and Its Ores," E. Blough, chemist, Aluminum Company of America.

Dec. 15, 1910.—"Operation and Enforcement of the Food and Drugs Act of June 30, 1906," M. C. Albrecht, chief of the United States Food and Drug Laboratory, Pittsburgh.

### Voltage Control of Transformers for Electric Furnaces.

In most resistance furnaces, like the graphite or the carborundum furnace, the variation of the resistance with change of temperature necessitates some method of varying the voltage, if it is desired to use a constant power throughout the operation of the furnace. This voltage control is especially important for large furnaces.

The chief methods in use for voltage control of transformers supplying energy to an electric furnace were described and discussed in an article by Mr. F. A. J. FitzGerald in our Vol. III, page 9. A new method has recently been devised by the General Electric Company for a 1600-kw, 25-cycle, single-phase transformer, installed at the plant of the International Acheson Graphite Company, at Niagara Falls; this method is described by Mr. E. F. Gehrken in a recent issue of the *General Electric Review*.

The transformer is wound for 2200 volts primary and 40 volts to 200 volts secondary, this range being obtained by means of taps in the primary and a series or parallel connection of the secondary. It is designed to deliver 1600 kw at any voltage within the range given; that is, it has a range in the current capacity of from 8000 amp at 200 volts to 40,000 amp at 40 volts.

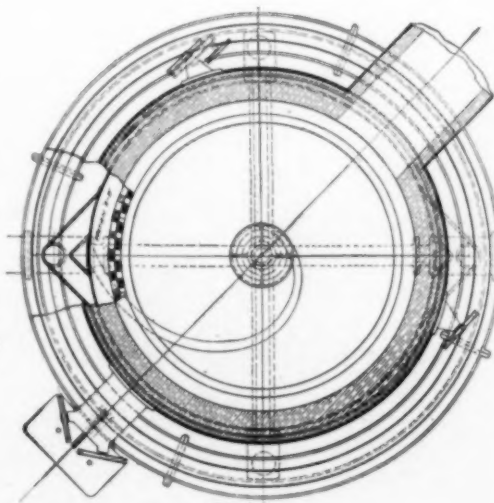
The method of voltage control is exceedingly simple and gives as nearly as can be determined by a voltmeter a perfectly smooth regulation. The controlling apparatus comprises a motor-operated 40,000-amp switch for connecting the secondaries of the transformer in series or in parallel (Fig. 1) and a switching device for changing the tap connections of the primary of the transformer. This switching device is shown diagrammatically in Fig. 2, and its arrangement is described in Mr. Gehrken's article as follows. It consists of the following parts:

1. Two dial switches *A* and *C* for changing the tap connections of the primary of the transformer.

2. A dial switch *B* for disconnecting the successive sections of the primary winding that have been cut out of circuit by dial switches *A* and *C*, so as to prevent excessive voltage across the transformer terminals which might occur as soon as the number of active turns of the primary windings are decreased.

3. A compensator, the winding of which is subdivided into a number of equal sections and arranged so that its terminals are consecutively connected across two adjacent taps of the transformer by means of the dial switches *A* and *C*; the terminals of this compensator being permanently connected to the moving arms of the two dial switches, respectively.

4. A cylinder switch with two sets of stationary collectors consisting of heavy bars, the two sets being arranged at right angles to each other and having the taps and the terminals of the compensators connected to one set, and individual resist-





ances to the other set. The moving member of the cylinder switch consists of a multiplication of fingers, individually insulated, by means of which the tap connection of the compensator is changed.

5. A two-part commutator controlling a contactor switch, by means of which the compensator circuit is opened as soon as the line is connected to a transformer tap direct and while the

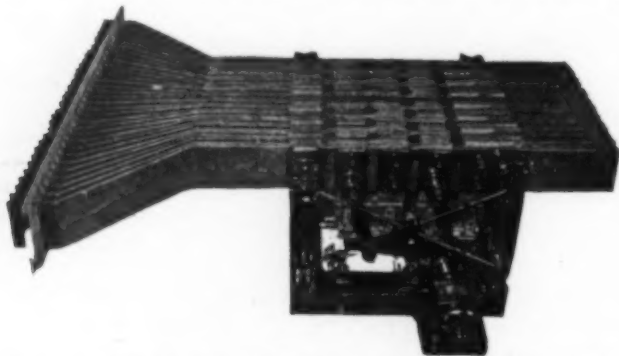


FIG. 1.—40,000-AMP MOTOR-OPERATED SWITCH FOR SECONDARY TRANSFORMER.

transformer tap connections are being changed by either dial switch *A* or *C*.

6. A voltmeter which is controlled by a rheostat and a potential transformer, and which indicates the voltage which will be obtained at the terminals of the furnace before the transformer is connected to the line.

7. An operating motor, shafts and gearing, by means of which the switches are operated; the motor being furnished with a reversing switch—so as to obtain a boosting or lowering of the transformer voltage—and a limit switch to prevent it operating the mechanism beyond the range of control.

The operating motor is geared to the shaft which, by intermittent gearing, actuates the dial switches *A* and *C* and the disconnecting switch *B*, and is connected to the cylinder switch by a crank. The odd numbered taps of the transformer are connected to the dial switch *A*, and the even numbered ones to the dial switch *C*; the ratio of the intermittent gearing is such that the moving member of the cylinder switch (designated as *P*) passes over the entire set of compensator collectors from top to bottom, or vice versa, for every change of connection of either dial switch *A* or *C*. The blades of these dial switches—which are shown as *X* and *Y*, respectively—are of sufficient width, and the spacing of the stationary clips *a*, *c*, *e*, etc., on switch *A* and *b*, *d*, *f*, etc., on switch *C* is such that each blade

remains in contact with each clip for an entire revolution of the crankshaft; that is, during the time necessary for the moving element *P* of the cylinder switch to travel over all of the contacts in both directions.

The crank operating the cylinder switch has an angular adjustment with reference to the blades *X* and *Y* of the dial switches, such that the change in the transformer tap connections of the dial switches takes place only when the crankshaft is on its centers, in which position the movement of *P* is exceedingly small. To compensate for this small movement both end collectors of the cylinder switch are made sufficiently wide to insure that all of the fingers of the moving element will remain on either end collector during the time required for changing the adjustment of either *X* or *Y* on switch *A* or *B*.

When the 2200-volt circuit is connected across the entire winding of the transformer, the minimum voltage will be secured across the secondary. This obtained with *X* on *a* and *P* connected to tap No. 1 of the compensator. With *X* on *a* *Y* is also connected to *b*, but practically no current flows through switch *C* with *P* on tap No. 1 of the compensator. The intermittent gear driving the dial-switch blades is inoperative with the blades in the position shown, with reference to the stationary clips *a* and *c* on switch *A*, *b* and *d* on switch *C*. The crank is just over the center and *P* is on tap No. 1 of the compensator. As the motor rotates, the contacts *X* and *Y* remain stationary, but *P* is moved along the horizontal collectors connected to the tap and terminals of the compensator, until it reaches the further extreme and the line is then, in effect, connected directly to the tap *b* of the main transformer. During this operation, the voltage of the secondary of the transformer has been gradually changed, because of the multiplica-

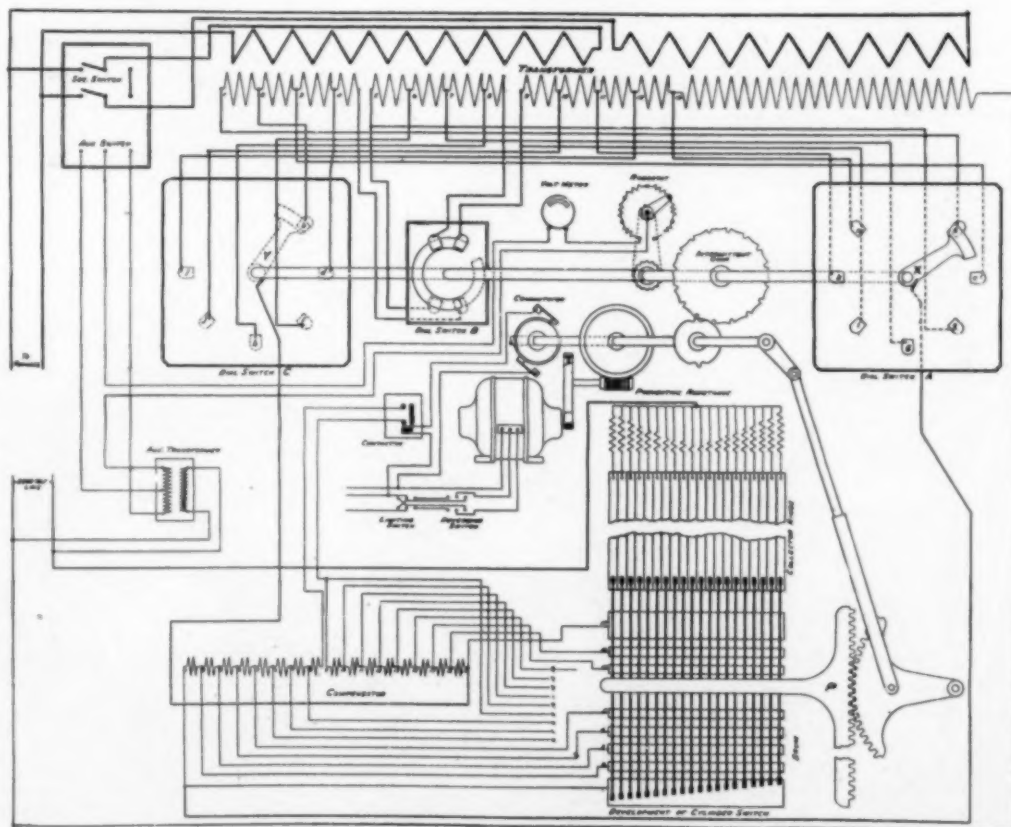


FIG. 2.—DIAGRAM OF CONNECTIONS FOR REGULATING DEVICE.

tion of the fingers on *P* and the large number of the taps on the compensator; the fingers *P* being arranged so that with the center of the top finger on the center of collector No. 3 of the cylinder switch, the center of the bottom finger is on the center

of collector No. 2 of the switch. As soon as *P* has reached the top collector of the cylinder switch, and the line is, therefore, connected direct to tap *b* of the transformer, the intermittent gearing engages and *X* is moved to *c*, *Y* still remaining on *b*. This changes the polarity of the compensator and again leaves *P* in a position such that by a continued movement of the crank the cylinder switch is again gradually changed between the next two transformer taps; that is, from *b* to *c*, thus again gradually increasing the secondary voltage of the main transformer. This alternating movement of the cylinder switch is continued until the entire range has been obtained.

With the secondary coils in multiple, the range in the secondary voltage of the transformer for a complete range of operation of the primary switch is from 40 volts to 100 volts. To obtain a higher voltage it is necessary to open the main

primary switch of the transformer and entirely disconnect it from the line; then to connect the secondary of the transformer in series by means of the motor-operated switch, shown in Fig. 1. The operation of the primary switch must then be reversed until the voltage across the secondary is again 100, after which the motor must be again reversed and the operation continued as before until the primary switch again reaches its limit. A voltage of 200, which is the maximum, will then be delivered by the secondary of the transformer.

In order to enable the operator to determine the adjustment of the switch in regard to the secondary voltage, before the transformer is again connected into circuit, a voltmeter connected to the secondary of a small potential transformer is provided, the primary of the latter being connected directly across the line from which the main transformer is operated. This potential transformer has a double winding, each of 100 volts,

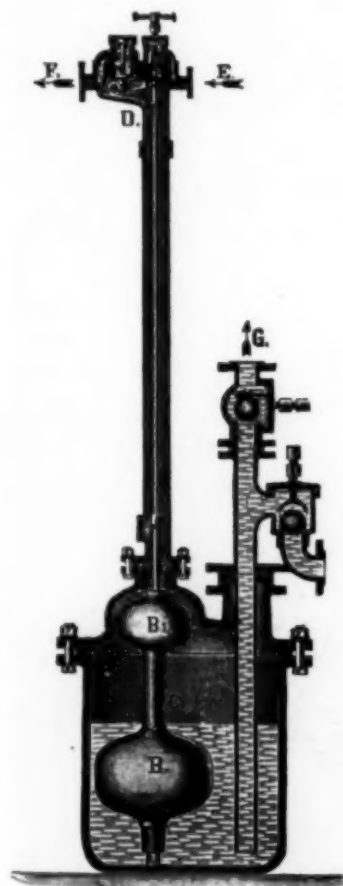


FIG. 1.—FLOAT-TYPE AUTOMATIC ACID EGG.

arranged as shown in the diagram, and by means of a small switch (operated by and simultaneously with the series-parallel switch for the secondary of the main transformer), either the full-voltage or the half-voltage arrangement is connected to the voltmeter, depending on whether the secondary of the main transformer is in series or in multiple.

The current from the potential transformer passes through an adjustable resistance, operated by a sprocket wheel and chain from the shaft which actuates the dial switches. This resistance is such that the voltmeter shows the approximate voltage of the secondary of the main transformer; that is, it not only shows the voltage when the transformer is in operation, but also when the main transformer is entirely disconnected from the line, it will show what the secondary voltage would be with any primary adjustment or secondary connection, if the primary were connected to the line.

In order to avoid breaking any current whatever by means of

the dial switches, a contactor switch is provided for this purpose. This contactor is excited from some suitable source of supply and controlled by a two-part commutator mounted on the main shaft. The brushes of the commutator are so adjustable that the contactor is normally energized, while the circuit is opened and thereby the commutator winding as soon as all of the fingers of *P* of the cylinder switch are on either extreme collector, and before either blade of either dial switch has opened the circuit. With this arrangement absolutely no current is broken by either of the dial switches *A* or *C*, the breaking of the magnetizing current of the compensator having been shifted to the contractor switch, the contacts of which are readily removable.

The burning of the contacts of *P* can be reduced to a minimum by having a large number of taps on the compensator, thereby reducing the voltage between the taps to a very small amount, and also by having a large number of fingers, so that there will be practically no breaking of the current, but rather a gradual shifting due to the gradually varied resistances between the compensator taps, which resistances have a sufficient capacity to allow the compensator switch to be left in any position whatever.

The arrangement described produces the same smooth and gradual regulation that is obtained with the induction regulator. The efficiency and power-factor of the installation are improved, and it is, therefore, particularly adapted for use with large single-phase low-voltage transformers having large current capacity and requiring a considerable range in voltage adjustment.

#### Automatic Acid Eggs and Gas Compressors.

Acid elevators and gas compressors play nowadays an important part in the equipment of a modern chemical works, and a short description of some new types should be of interest.

Fig. 1 shows Schütze's float-type automatic acid egg, which is built along the ordinary lines, but contains a few improvements in its general design. Its action is as follows:

The liquid flows by gravitation through a check valve into the elevator. During this period the dead weight of the double float *C* (consisting of two rigidly connected balls *B* and *B1*) acts on the lever *D* in such a manner that the compressed air (or steam) inlet *E* is kept closed, while the outlet valve *F* is open, allowing the air displaced by the liquid to escape. When the liquid reaches the upper part of ball *B*, the float rises, whereby air outlet *F* is closed, and the air inlet valve *E* opened. The compressed air then presses upon the surface of the liquid which is forced through delivery pipe *G*. When the surface of the liquid reaches the lower ball *B*, the float sinks, closing the air inlet valve. The compressed air expands until the egg is nearly emptied, but before the air can enter the delivery pipe, the air outlet valve *F* opens, and the cycle of operations is repeated.

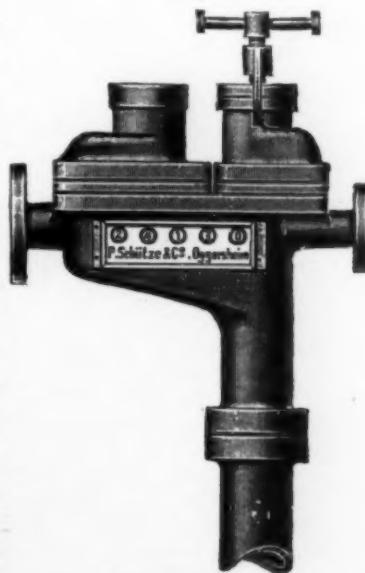


FIG. 2.—COUNTING APPARATUS.



The elevator performs from 30 to 60 operations per hour, according to the varying circumstances. As the quantity of liquid discharged at each operation is always the same, the daily or weekly output can be controlled by means of a counting apparatus, registering the number of pulsations, as shown in Fig. 2.

Owing to the fact that this elevator works with expansion, the air consumption is very economical. For instance, it takes 100 cu. ft. of air hourly under a pressure of 70 lb. per square

filter presses, these elevators are provided with agitators to prevent settling of the solid matter. The method of operation is as follows:

The liquid to be pumped flows through the inlet valve into the montejus, which forces it periodically into the receiver. Since the receiver is constantly under air pressure, the liquid is driven out in a continuous stream. When the montejus is empty the back pressure valve closes, and the inflow into the montejus commences afresh. A shut-off valve must be fitted in the discharge pipe of the receiver for regulating the outflow so that it does not exceed the amount of liquid supplied by the montejus.

Schütze's single and double-acting and compound gas compressors, as illustrated in Figs. 4, 5 and 6 respectively, are of a similar design and offer the advantages of having no stuffing boxes, piston or other working parts subject to friction.

The pump cylinder *E* alone comes in contact with the gas or vapor to be compressed, and can be supplied of earthenware, cast iron, wrought iron, etc.

Their construction is clearly shown in the accompanying cuts, and needs no further explanation.

An entirely new design is represented by Schütze's automatic acid elevator with electric valve gear.

By this arrangement all floats, bells, etc., in the interior of the acid egg are dispensed with, and the latter contains no

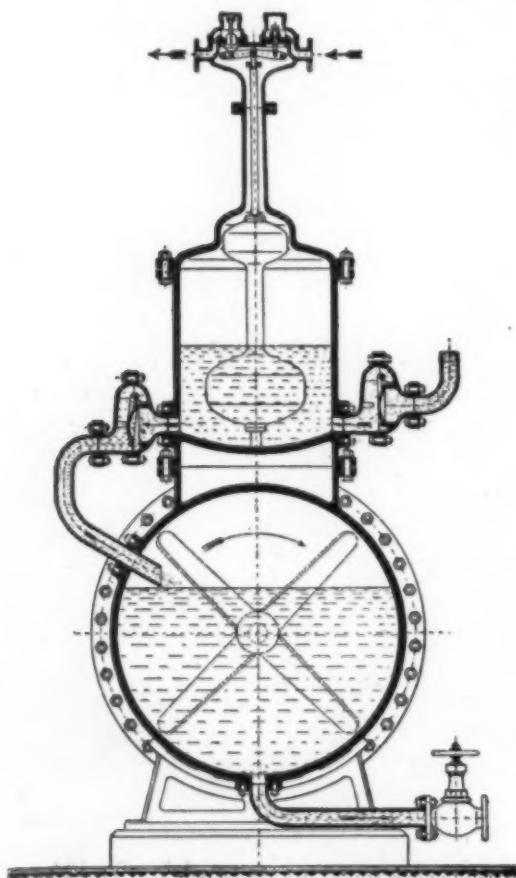


FIG. 3.—CONTINUOUS-FLOW ELEVATOR.

inch to raise 1000 gal. of liquid per hour against a pressure of 45 lb.

In many works engaged in the chemical industry, it is desirable, if not absolutely essential, to convey liquids to their place of destination in an uninterrupted stream, and for this purpose power-driven piston pumps, rotary pumps, injectors, etc., have hitherto been used.

All these appliances, however, are little, if at all, adapted for corrosive, muddy acid or caustic liquors, because the various working parts are quickly destroyed and the whole apparatus is, therefore, soon rendered useless.

Acid eggs or elevators, on the other hand, whether automatic or operated by hand, all work periodically and are, therefore, not adapted for the above purpose.

To fill this want, Schütze's continuous-flow elevator has been designed to furnish an apparatus embodying the qualities of both the pump and the acid egg.

This elevator, illustrated in Fig. 3, delivers the liquid in a regular uninterrupted stream without shock and is therefore particularly adapted for feeding filter presses, cooling and absorption towers, and other similar purposes. As it does not contain any parts subject to friction the power consumption is very economical.

For muddy liquids, and especially those used for feeding

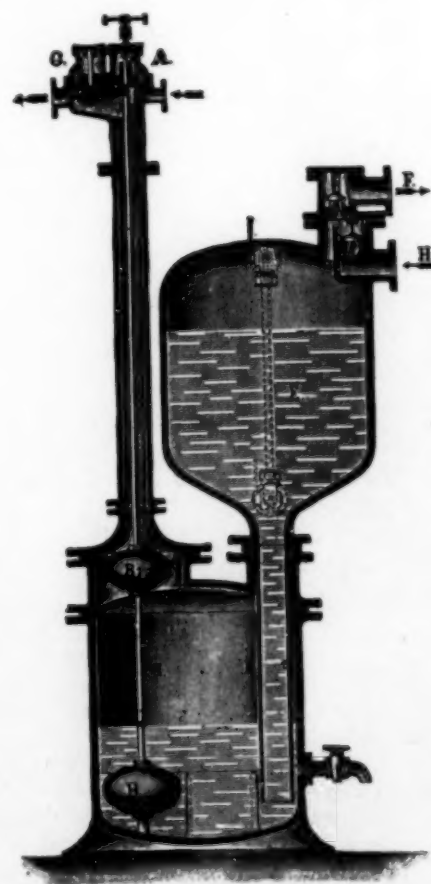


FIG. 4.—SINGLE-ACTING GAS COMPRESSOR.

movable parts, but only a set of contacts, which pass through a stuffing box and are insulated from the metal of the egg.

The working of the apparatus (Fig. 7) is as follows: The liquid is admitted by the valve *i*, and first reaches the outer contact tube *a*. When the egg is completely filled, the liquid reaches the external contact *c*, and completes an electric circuit. The electromagnet now becomes active and lifts the air inlet *d*. Compressed air is admitted, which closes the exhaust

valve *e*, and forces the liquid out of the egg into the rising main. As soon as the level of the liquid sinks below the edge of the contact tube *a*, the circuit is opened and the electromagnet releases the inlet valve, which closes and cuts off the supply of compressed air. The rest of the liquid and the compressed air contained in the egg escape through the rising main, the exhaust valve *e*, which slightly loaded by a deadweight *g* opens, and the egg again begins to fill.

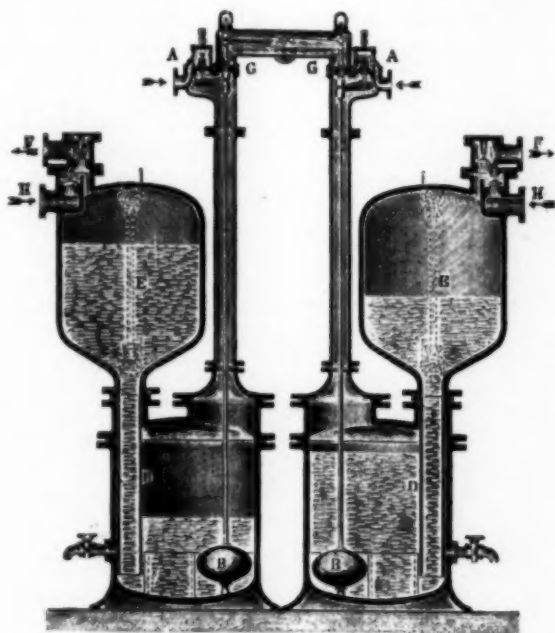


FIG. 5.—DOUBLE-ACTING GAS COMPRESSOR.

A brief explanation of the peculiar arrangement of contacts may be of interest. The tube *a* is connected to one terminal, while the rod *b*—which is, of course, insulated from *a*—and the rod *c* are connected to the other terminal. As the liquid fills the egg, it surrounds the tube *a*, without, however, rising into

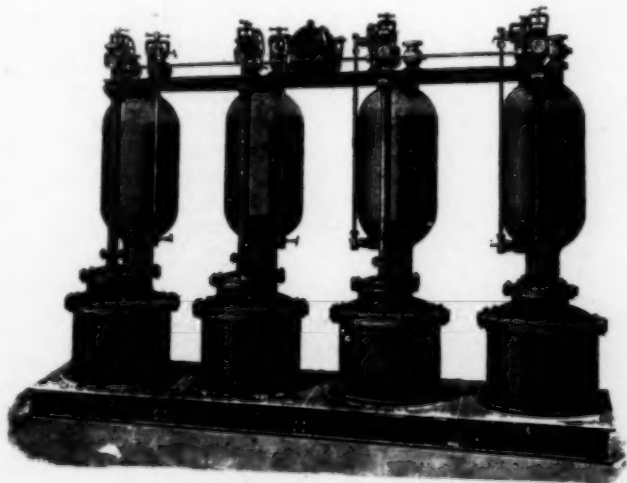


FIG. 6.—COMPOUND GAS COMPRESSOR.

it, as the tube is closed at the top. When it fills the egg it reaches the contact *c*, thus closing the circuit, actuating the electromagnet and admitting compressed air, as already explained. This forces the liquid up into the tube *a* and above the contact *b*, so that the circuit remains closed, although the level of the liquid sinks and leaves the contact *c* exposed. Only when the egg has emptied does the liquid blow out of the tube *a*; the circuit is opened and the compressed-air inlet valve *d* is released by the electromagnet and closes, as described above.

The simplicity of the apparatus and its absolute reliability in action are obvious. There are no floats, which must always be adapted to a certain specific gravity, and cause occasional trouble by sticking in even the best-designed apparatus. The valve gear is connected to the egg only by two wires, and may, therefore, be placed in any convenient position. Existing acid eggs may be transformed into automatic ones simply by the ad-

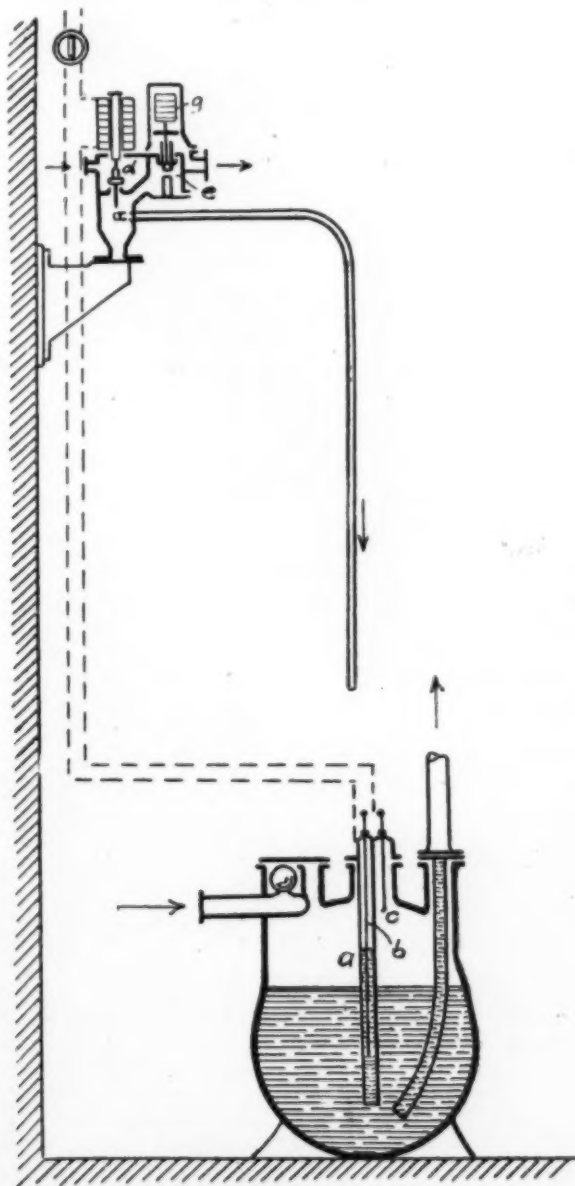


FIG. 7.—AUTOMATIC ACID ELEVATOR, WITH ELECTRIC VALVE GEAR.

dition of the valve gear and the insertion of the contacts. The latter, as well as the egg itself, can easily be made of material suitable for any liquid.

These automatic acid eggs and gas compressors of Schütze are introduced in this country by Mr. A. Innerhofer, 30 Church Street, New York, N. Y.

The New York Section of the American Chemical Society will hold a meeting on June 2. The program of the evening contains papers by Charles Baskerville and W. A. Hamor on the examination of ethyl ether, by M. A. Rosanoff on vapor pressures of binary mixtures, by F. J. Pond on iron corrosion, by A. E. Hill on the constancy of the solubility product, by H. C. Sherman and E. C. Kendall on amylases.



### Constitution of Water.

A general discussion, of considerable theoretical interest, was held at the last meeting of the Faraday Society, in London, on the subject of the constitution of water.

Prof. P. WALDEN, of Riga, Russia, made the first contribution in the form of a paper entitled "Is Water an Electrolyte?" The paper included a number of observations that had been made in order to determine whether water when dissolved in a medium possessing powerful ionizing properties might not itself become an electrolyte.

To secure an adequate answer to this question it was considered necessary to make use of media of which the specific inductive capacity was greater than that of water. The liquids selected were hydrogen cyanide (HCN), formamide (H-CO-NH<sub>2</sub>), nitrosodimethylamine ((CH<sub>3</sub>)<sub>2</sub>N-NO), formic acid (H-CO-OH) and sulphuric acid, the first two solvents being characterized by a specific inductive capacity greater than 84, the value for water. In passing it may be noted that Professor Walden's discovery of the use of formamide as a solvent represents a "find" of extraordinary importance, which even if it stood alone would form an adequate recompense for the labor involved in his survey of the wide field of organic liquids; this solvent appears to reproduce nearly all the valuable qualities of water, including its convenient freezing point and boiling point and its powerful ionizing properties, but will mix freely with important groups of compounds which do not dissolve to any marked extent in water.

Hydrogen cyanide, which, with its high specific inductive capacity and great fluidity provides ideal conditions for electrolysis, was found when used as a solvent for water to give molecular conductivities of the order of 0.009 as contrasted with 300 for a salt such as potassium iodide; the low molecular conductivity of the water dissolved in hydrogen cyanide finds a parallel, however, in the low conductivity of hydrogen cyanide dissolved in water. Formamide, with a similar specific inductive capacity, but much smaller fluidity, gave for molecular conductivity of water values (about 0.016) only slightly higher than in the case of hydrogen cyanide. In the case of formic and sulphuric acids the specific inductive capacity is lower than that of water, sulphuric acid being further handicapped by its extraordinary viscosity, but both solvents gave increased values for the molecular conductivity of water, namely, about 0.17 in formic acid, but rising in the case of sulphuric acid as high as 74.

From these observations it is clear that the conductivity attributed to the water does not depend on the physical qualities of the solvent, but on some chemical relationship between solvent and solute. It was suggested by the author that water, acting as an amphoteric electrolyte, could form a salt when mixed either with a strong acid or with a strong base, and that the high conductivity of mixtures of sulphuric acid and water and the slight conductivity of mixtures of formic acid and water, were due neither to free acid nor to free water, but to the presence of an oxonium sulphate or formate in the liquid. The absence of conducting power in mixtures of water with hydrogen cyanide or formamide was attributed to the weakness of their acidic and basic qualities and the impossibility of combining them with water to form a salt-like electrolyte.

Prof. PH. A. GUYE, of Geneva, Switzerland, having given a résumé of the results of diverse researches concerning the phenomena of molecular association, conducted both in his laboratory at Geneva and in that of Prof. P. Dutoit at Lausanne, showed how the conception according to which association was a simple phenomenon of chemical polymerization permitted of our predicting various properties of associated liquids. He then indicated that it was even possible to calculate the order of magnitude of the association factor  $x$  in the liquid phase, if the degree of association or of dissociation were known in the vapor phase.

Mr. W. R. BONSFIELD and Dr. T. M. LOWRY then read a paper

on "Liquid Water a Ternary Mixture; Solution-Volumes in Aqueous Solutions."

Mr. W. SUTHERLAND sent a written communication to the discussion in which he brought forward the view that water of crystallization is solid hydrol in a special state. According to the writer's theory water vapor when nearly a perfect gas is hydrol, H<sub>2</sub>O. Ice is trihydrol, (H<sub>2</sub>O)<sub>3</sub>. Water is a mixture of trihydrol and dihydrol, (H<sub>2</sub>O)<sub>2</sub>, in varying proportions, at ordinary temperatures containing about one part of the former to two of the latter. The formula (H<sub>2</sub>O)<sub>3</sub> for ice explains its crystalline form, the hexagonal prism. This the author pictures, assuming the electron theory of valency, according to which tetravalent O is an atom associated with three negative and one positive electrons, the electron pair being available for the purpose of joining the three oxygen atoms together, while the two negative electrons attach it to two H atoms through their positive electrons. From the kinetic theory of gases it is calculated that such a trihydrol molecule has a density of 1.2. The density of ice, however, is 0.917, hence the hydrol molecule is larger than is supposed by the theory. In water of crystallization one has a form of solid hydrol; the physical properties of this are dealt with in an Appendix. The mean volume of H<sub>2</sub>O in water of crystallization found by Clarke from 31 separate volumes is 13.76 cc for 18 grammes, giving a density of 1.31 for solid hydrol, compared with 0.917 for ice, or trihydrol.

The author next applies the hydrol theory to the consideration of solutions. He regards the ionization of all electrolytic solutions as complete at all strengths. The so-called degree of ionization is really the relative mobility of the ions; the original ionic theory ignored the electric forces acting between the ions and the ionizing forces keeping the ions apart. When the ions are moved past one another in solution by means of an e.m.f. two viscosities of electric origin are encountered, one due to the electric forces between the ions and the water molecules and the other due to neighboring ions. Thus the mobility of an ion is proportional to the cube root of the concentration; the hypothesis of chemical union between ion and solvent is as unnecessary as the theory of partial ionization. Nevertheless a term is required for the mutual energy of ion and solvent. This theory explains Walden's law on the dependence of ionic mobility on dielectric capacity and Ostwald's valency rule.

The effect of the solute on the solvent is also discussed. The contraction occurring when electrolytes are dissolved is due to their changing some of the trihydrol into dihydrol. A positive ion changes tri- into di-hydrol, a negative di- into tri-hydrol. To explain the apparent partial ionization in the case of weak organic acids, the author suggests that these consist of double molecules, some of which are dissociated into single molecules, these being completely ionized.

Prof. W. NERNST communicated a paper on "The Specific Heat of Ice, Water and Steam," which was read by Dr. W. T. M. WILSMORE. The survey covers the whole field from -200° C. to the highest temperatures. At low temperatures the specific heat is calculated by means of the thermo-dynamical theorem established by the writer. The variations in the specific heat of steam under high pressure are accounted for on the assumption of the polymerization  $2\text{H}_2\text{O} = (\text{H}_2\text{O})_2 + 2519$ . The values for water vapor at very low temperatures are those deduced from kinetic theory. Attention is directed specially to the minima in the specific heat of water vapor under moderate pressures and of liquid water at moderate temperatures. Both minima are attributed to the dissociation of complex molecules.

Messrs. H. B. BAKER, V. H. VELEY, F. P. SEATON, W. R. BONSFIELD, G. SENTER, and W. P. DREAPER also participated in the discussion. Mr. Baker gave a striking experimental demonstration of the influence of purification in retarding the action of water on sodium amalgam. The conductivity of the water was a little lower than two reciprocal megohms. It is probable that non-conducting water, if it could be obtained, would be perfectly inactive chemically. Dr. Veley described similar experiments on the inactivity of highly purified nitric acid.

## NOTES.

**Dry sizing of ores** for subsequent magnetic treatment can be successfully carried out in trommel screens as fine as 15 mesh where the conditions are right. If the mineral particles do not fracture in too sharp or very angular fragments, the trommels will not blind and will show good capacity. Some mixed sulphides of iron and zinc will show very good results by this method of sizing.

**The Nissen Stamps** operating on disseminated copper ores in a porphyry gangue show a capacity of between 9 and 10 tons per day per stamp, screening to 26 mesh. The stamp heads are 10 in. in diameter, weight 1500 lb., drop 105 times per minute with a height of drop of  $6\frac{1}{2}$  in.

**Extension of the riffles** of the Wilfley concentrating table frequently produces an effect which may be valuable under certain local conditions. With extra high riffles extending the full length of the bed of the table a rough concentrate can be produced which will increase the capacity of tables used later in the flow of the ore. This is the effect produced in the so-called Garfield table. Still other effects of more or less value can be produced by extending the riffles to the end of the table, but at a slight angle, say,  $10^\circ$  toward the side of the table. Such alterations are valuable only under special conditions and must be determined by experiment.

**Removal of Scrap Iron and Steel from Ore.**—The inevitable occurrence of small pieces of drill steel, nails and scrap iron of various kinds in ore delivered to the mill may cause considerable damage to the crushing plant if not removed. A very efficient way to remove such material is to use a magnetic feed sole just before the first crusher. The electromagnet can be made as strong as necessary to attract and hold pieces of steel as heavy as 8 lb. to 10 lb., without allowing them to be brushed off by the stream of ore. When the accumulation becomes sufficient to interfere seriously with the feed, the current can be cut off and the pieces of scrap removed. The quantity of material removed will often be surprisingly large.

**The removal of wood from mill ore**, prior to the finer stages of crushing and grinding, will contribute materially to the capacity of the plant. A simple device for accomplishing this has been installed in the concentrator of the Colusa Parrat Company at Butte, Mont., by Mr. Fred Pratt. After the first crushing and prior to entering the trommel system, the ore is elevated and discharged into a bin filled with water. The ore sinks through the water and is directed by the sloping sides of the bin to a point where it is removed by a bucket elevator. The wood floats and is discharged through an overflow launder or removed by an attendant. This simple device has been the means of greatly increasing the capacity of the concentrator.

**The University of Montana** senior class in mining engineering and metallurgy took its annual trip through Western mining and metallurgical centers last month. The party consisted of 30 men and was in charge of Prof. R. H. Bradford, of the department of metallurgy. In Montana the party studied the mining methods at Butte and the concentrating smelting and refining of copper at Anaconda. Lead smelting was studied at Helena and copper smelting at Great Falls. In the Coeur d'Alene district, Idaho, the lead mines and concentrating mills were visited.

**Institute of Metals.**—The (British) Institute of Metals will hold its annual autumn meeting in Glasgow on Sept. 21 and 22. A local committee, with Prof. Archibald Barr as chairman and Dr. Cecil H. Desch as secretary, has already been formed.

**The Forest Products Laboratory** at Madison, Wis., will be formally opened on June 4. It is a co-operative undertaking between the United States Department of Agriculture and the University of Wisconsin. This is perhaps the largest and best-equipped wood-testing laboratory in the world. It will be prepared to make tests on the strength and other properties

of wood, to investigate the processes of treating timber to prevent destruction by decay and other causes, to study the saving of wood refuse by distillation processes, to examine the fiber of various woods for paper and other purposes, and to determine the influence of the microscopic structure of wood on its characteristics and properties.

**The Griscom-Spencer Company** of New York City, manufacturers of the Osborne blast separating and collecting apparatus and of other apparatus for chemical factories, have lately undertaken the designing of complete manufacturing equipment and the construction of factories for chemical products.

**The Hardinge Conical Mill Company**, of New York City, have sent us their new, well-written and neatly illustrated catalog, entitled "Advantages of the Hardinge Patent Mills Over Other Grinding Devices." The Miami Copper Company has ordered four Hardinge conical mills to be shipped to Globe, Ariz.; this is the fourth large copper company in the United States to adopt the Hardinge mill. The New Einasleigh Copper Company also have one en route to their plant in Australia. The Automatic Gold Separator Company will also use a Hardinge mill in their test plant at Los Angeles, Cal. A 6-ft. diameter sectionalized ball mill has been shipped by the Hardinge company to the Grand Union Mining Company, Choix, Mexico. Messrs. Frazer & Chalmers, of London, England, have been appointed special sales agents for the Hardinge mill in Africa and Great Britain.

**The National Lead Company**, of St. Louis, Mo., is making extensive changes and improvements in its plant there, which include an almost entire new power equipment. The contract for the apparatus has been awarded to Allis-Chalmers Company and includes two 20 x 42 heavy-duty Corliss engines. One of these will be direct-connected to a 250-kw, 240-volt, 110-r.p.m. generator and the other will be provided with a rope flywheel for driving shafting. In addition there will be a 100-kw, 240-volt generator for direct-connection to high-speed engine, 14 240-volt motors ranging from 5 hp to 50 hp, and a six-panel switchboard.

**Silica Standards of Length.**—The silica bar standards of length of the (British) National Physical Laboratory, mentioned on page 257 of our May issue, were made by the Silica Syndicate, Limited, London. By a mistake a different firm was named as manufacturer in our former notes.

**Thermometers.**—We have received from the Bristol Company, of Waterbury, Conn., their bulletin 125, describing Bristol's Class 1 self-contained recording thermometers for recording temperatures at the point where the instrument itself is. These are now being used to good advantage for recording temperatures in cold-storage plants. Some new models of Bristol thermometers are also illustrated.

**Power Development Along Canal.**—The old Ohio Canal is now serving a purpose never intended by its builders. Power sites are being developed along its banks and feeders, and the latest of these is one at Roscoe, controlled by the Coshocton Heat & Light Company. This company is largely increasing its power equipment and has recently installed a 750-kw Allis-Chalmers steam turbo-generator in its power house at Coshocton. It has now placed an order with the same company for a 1600-hp twin-horizontal open-flume hydraulic turbine direct-connected to a 1000-kva, 4000-volt, three-phase, 60-cycle alternator. The turbine is designed to operate under a head of 32 ft.

**Buying Coal on Specifications** and paying for the heat value contained has been growing in favor for the past year or two. The United States Government, being a very large consumer of coal for use in the navy and in public buildings, has quite naturally given the subject some attention. Bidders for a part of the government's coal supply specify a definite standard for their product, and this standard is taken into consideration in awarding the contract. Then any deliveries of fuel falling



below the specified standards are subject to a penalty, and similarly all shipments having a greater fuel value than that specified in the contract are entitled to a premium. The value of the fuel is, of course, determined by chemical and calorimetric tests. The United States Geological Survey has recently issued Bulletin 428, giving a statement of the factors affecting the value of coal, the methods for sampling and testing it, a form of specifications used, and a statement of the operation of the plan in 1908-9.

**Steam Turbines.**—A recent sales report of the Steam and electrical department of Allis-Chalmers Company shows how favorably the steam turbine has been received as a prime mover by users of power. A little over four years ago the company obtained the right to manufacture in this country the latest improved type of Parsons machine. The end of the first year saw only one unit in operation, but since then there has been a steady and rapid growth in sales, which has reached a total capacity of over 300,000 horse-power. Of this aggregate 48.2 per cent were sold during 1909 and 20.6 per cent have been placed on orders since January 1, 1910. A larger proportion of the units have been for use by power, lighting and railway companies and approximately 40 per cent of the total sales were for this purpose, textile manufacturers being next with 14 per cent of the machine. Practically every type of industrial enterprise is represented in the buyers of these turbines, including gas plants, cement mills, mines, lumber mills, flour mills, paper factories, tanneries, celluloid works, etc. In geographical distribution the machines are to be found in nearly every State in the Union and also in Canada and Mexico.

**"High Vacuum Surface Condensers for Steam Turbines"** is the title of Bulletin 106, just published by the Wheeler Condenser & Engineering Company, of Carteret, N. J. The high steam economy obtained by steam turbines with vacuums of 28 in. to 29 in. is pointed out, while on the other hand it is shown that in obtaining these high vacuums there should be no unnecessary power consumption by the condenser auxiliaries, or excessive amounts of water used for cooling purposes. This pamphlet describes arrangements of the tube surface, the use of rain plates and other means recently devised for obtaining these results. The construction of the Wheeler dry tube condenser is the outcome of investigations into the several factors affecting transmission of heat through condenser tubes, such as the material and cleanliness of the tubes, the velocity of water within the tube, the velocity of steam against the tube, the percentage of air in the steam surrounding the tube, and whether or not the steam side of the tube is flooded with water. Copies of this Bulletin, which is illustrated by numerous photographs and drawings, will be sent upon request by the Wheeler Condenser & Engineering Company, of Carteret, N. J.

#### PERSONAL.

**Dr. Richard Amberg**, formerly with the American Steel Foundries, of Indiana Harbor, Ind., has accepted a position with the Crucible Steel Company of America in connection with their plans for the erection of electric steel furnaces.

**Mr. E. P. Mathewson**, general manager of smelting operations for the Anaconda Copper Mining Co., of Anaconda, Mont., and the International Smelting & Refining Company, was in Salt Lake City early in May on a trip of inspection to the new Toole plant of the latter company.

**Mr. I. J. Moltkehanen**, who will be remembered by many American electrochemists from his stay in this country several years ago, and who was later connected with Mr. Ashcroft in an electrolytic sodium factory in Norway, has opened a Comptoir de Chemie at 37 Boulevard de le Senne (near Gare du Nord), Brussels, Belgium, having bought an old-established business of chemicals and laboratory apparatus. He intends to make a specialty of representing American firms. He will

also continue to act as consulting engineer for Norwegian waterfalls, being in contact with owners of from 2 hp to 300,000 hp.

**Mr. Oscar Spitzer** recently left Butte, Mont., en route to Australia, via Japan, on a business trip in the interest of Beer, Sondheimer & Company.

**Mr. Henry N. Thomson** is manager of the Toole plant of the International Smelting & Refining Company at Toole, Utah.

#### Digest of Electrochemical U. S. Patents.

Prior to 1903.

*Arranged according to subject matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

**ELECTRIC FURNACES (Continued).**

No. 672,054, April 16, 1901, G. de Chalmot, Holcombs Rock, Va.

Arc or resistance type, especially for production of titanium and its alloys. The charge is placed in a crucible of carbon, covered by a plate. The crucible is supported in an outer chamber of firebrick by bars of carbon passing through the outer walls and having beveled ends bearing against the crucible. The firebrick chamber is covered above and is vented by passages in its bottom. This chamber is carried by a truck. Fixed on the truck is a framework carrying a vertically adjustable carbon electrode which passes through the bottom of the chamber and up to or nearly to the bottom of the crucible. An electric current is passed successively through this electrode, the crucible and the support bars, generating heat either at points of imperfect contact between the crucible and electrode or bars, or springing an arc to the bottom of the crucible. Carbon monoxide or water-gas may be introduced through one of the vent passages.

No. 672,067, April 16, 1901, F. J. Patten, New York City.

Arc type, especially for production of calcium carbide. The furnace has three flat open-hearths, sectors of a circle, pivoted on a central post. Each sector occupies an arc of 70° and rests on ball bearings. Pairs of electrodes depend from a swinging arm over each hearth, an arc being sprung between their ends and being electromagnetically deflected downward to the hearth. While the material on two hearths is being smelted, the third is discharged and recharged. The electrodes are radially adjustable over the hearths. Three arcs supplied with three-phase current may act on each charged hearth, or two-phase current may be used.

No. 672,601, April 23, 1901, O. Froelich, Steglitz, Germany.

Arc type, especially for calcium carbide. The furnace is a crucible with refractory lining. A tubular carbon electrode depends into the crucible, an arc being sprung between their lower ends. A bent discharge tube of iron extends from a tap-hole in the bottom of the crucible, and is normally closed either by a flexible end-piece of asbestos hose or by a hinged cover. The iron tube is counterbalanced, and its upper end is heated by burning the gases from the upper tubular electrode in a casing surrounding it.

No. 676,575, June 18, 1901, Alfred H. Cowles, Cleveland, Ohio.

Water-cooled electrode holder for furnaces with gas-reversing flues of prior patents. The holder is a vertical metal tube closed at both ends, the lower end having a socket for the electrode and the upper end carrying an adjusting screw. A small concentric inner tube forces a stream of water down against the socket end and the heated water escapes through an outlet pipe at the top. The furnace has a water-jacket, to which the other electric conductor is attached.



## NEW BOOKS.

ARMES, ETHEL. Story of coal and iron in Alabama. 615 pages, illustrated. Price, \$5. Birmingham, Ala.: Ethel Armes.

BLANCHARD, ARTH. ALPHONZO. Synthetic Chemistry. Second edition. Price, \$1. New York: John Wiley & Sons.

BLANCK, F. CONRAD. Nitration of aniline and certain of its derivatives. Price, 40 cents. Baltimore: Johns Hopkins University.

BURCHARD, ERNEST F.; C. BUTTS AND E. C. ECKEL. Iron ores, fuels and fluxes of the Birmingham district, Alabama. 204 pages, illustrated, Washington, D. C.: U. S. Geological Survey.

CHESNEAU, GABRIEL. Theoretical principles of the methods of analytical chemistry based upon chemical reactions; authorized translation by Azariah T. Lincoln and D. Hobart Carnahan. Price, \$1.75 net. New York: Macmillan Company.

CORDEIRO, F. JOAQUIN BARBOSA. The atmosphere; its characteristics and dynamics. Price, \$2.50. New York: Spon & Chamberlain.

CRAM, MARSHALL PERLEY. Fractionation of crude petroleum by capillary filtration. 50 pages, illustrated. Price, 50 cents. Baltimore: Johns Hopkins University.

ENNIS, W. DUANE. Linseed oil and other seed oils; industrial manual. Price, \$4. New York: Van Nostrand Company.

GODFREY, HOLLIS. Laboratory manual to accompany Godfrey's "Elem. Chemistry." 36 cents. New York: Longmans, Green & Company.

GOLDINGHAM, ARTH. HUGH. Design and construction of oil engines, with full directions for erecting, testing, installing, etc. Third edition, revised and enlarged. Price, \$2.50. New York: Spon & Chamberlain.

GREGORY, HERBERT ERNEST; KELLER, ALBERT GALLOWAY AND BISHOP, AVARD LONGLEY. Physical and commercial geography; study of certain controlling conditions of commerce. Price, \$3. New York: Ginn & Company.

HANCOCK, EUG. T. Notes accompanying the lectures on geology applied to mining; course given at Michigan College of Mines. Price, \$1. Lancaster, Pa.: New Era Printing Company.

JONES, HARRY CLARY. Introduction to physical chemistry. Price, \$1.60 net. New York: Macmillan Company.

LEEDS, FK. H., AND BUTTERFIELD, W. J. ATKINSON. Acetylene: principles of its generation and use. Practical handbook on the production, purification, and subsequent treatment of acetylene for the development of light, heat and power. Second edition. Price, \$2.50 net. Philadelphia: Lippincott.

MORDEN, GILBERT WALWORTH. Determination of thallium in the electrolytic way. 14 pages, illustrated. Philadelphia: University of Pennsylvania.

PURIFICATION OF WATER FOR BOILER FEEDING. Compiled by the Harrison Safety Boiler Works for the confidential information of its agents and employees. 105 pages. Philadelphia: Harrison Boiler Works.

RICHARDS, ELLEN HENRIETTA SWALLOW. Laboratory notes on industrial water analysis; survey course for engineers. Second edition revised. 59 pages. Price, 50 cents net. New York: John Wiley & Sons.

RIPPER, W. Heat Engines. (Being a new edition of "Steam.") Price, 90 cents net. New York: Longmans, Green & Company.

STUNTZ, STEPHEN CONRAD. Reference list on the electric fixation of atmospheric nitrogen and the use of calcium cyanamide and calcium nitrate on soils. 89 pages. Washington, D. C.: Department of Agriculture, Bureau of Soils.

UNITED STATES DEPARTMENT OF THE INTERIOR, U. S. GEOL. SURVEY. Colloid matter of clay and its measurement by Harrison Everett Ashley. 65 pages, illustrated. U. S. Supt. of Docs.

TAINTOR, C. WILSON. Brief analysis of the United States Steel Corporation, with chart of quarterly earnings since its organization. Price, \$3. C. W. Taintor.

TAYLOR, ALEX. JA. WALLIS. Sugar machinery. Descriptive treatise devoted to the machinery and apparatus used in the manufacture of cane and beet sugars. Second edition, enlarged and extensively revised. 184 pages, illustrated. Price, \$2 net. New York: Van Nostrand Company.

THOMPSON, SILVANUS P. Life of William Thomson, Baron Kelvin of Largs. Price, \$7.50 net, boxed. New York: Macmillan Company.

TIBBALS, C. AUSTIN, JR. Study of tellurides. 421 pages, illustrated. Price, 25 cents. Madison, Wis.: University of Wisconsin.

WARREN, W. H. Engineering construction in steel and timber. Second edition. Price, \$5 net. New York: Longmans, Green & Company.

WILLARD, G. H., AND CRAWSHAY, FRED DUANE. Pattern-making, core-making and molding. Price, \$1. Chicago, Ill.: Popular Mechanics.

## BOOK REVIEWS.

**Report on the Iron Ore Deposits Along the Ottawa and Gatineau Rivers.** By Fritz Cirkel, M. E. 147 pages, illustrated. (Series of bulletins on the mineral resources of Canada, issued under the direction of Dr. Eugene Haanel, Director of Mines.) Ottawa, Can.: Mines Branch, Department of Mines.

This is a report on an investigation of the iron ores of the valleys of the Ottawa and Gatineau Rivers. It is of special timely interest in view of the endeavors which are being made to establish an electric iron and steel industry in this region which possesses great water-powers.

After describing in detail various iron ore deposits in the townships of Hull, Templeton, Wakefield, Bristol, Grenville, and others, Mr. Cirkel concludes that many of these would yield ores which could in all probability be treated profitably in the electric furnace. It is stated in the report that this method of reducing the iron ores can compete with the blast furnace for the production of pig iron, if electrical energy can be developed at a low cost. With respect to the possibilities of the electrometallurgy of iron and steel the general conclusions on pages 100 to 107 are of special interest.

An appendix to the report gives a synopsis of the water powers, both developed and undeveloped, in the region under consideration. These data have been compiled from the latest authoritative sources available. The following falls can be developed to produce large quantities of power: Paugan Falls, Cascades, Chelsea Rapids, Great Falls, Coulonge River, Roche Fendue, Calumet Falls, Chats Falls.

The Mines Branch of the Department of Mines and Director Dr. Eugene Haanel must be congratulated on their untiring efforts to lay a solid foundation for a new Canadian industry.

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**Verhalten der Wichtigsten seltenen Erden zu Reagentien.**

**Zum Gebrauch im Laboratorium.** Von Dr. Jos. v. Panayeff. 83 pages. Price, marks 3.60 (retail price in New York, \$1.15). Halle a. S.: Wilhelm Knapp.

This is apparently one of the series of German laboratory books for the chemical industries edited by L. Max Wohlgenuth and published by William Knapp, though this is not stated on the title page or cover. At any rate, the appearance of the little book is most timely. The author claims to have made many new observations regarding the behavior of these elements with reagents different from those before published and that in this respect his book differs from most other works on the subject in that he does not offer the results of the observations and investigations of others, but rather the

results of his own work, and only statements which he has, himself, confirmed.

No attempt is made in the book to lay down methods for separation of the metals from each other or from other better known elements, but attention is concentrated upon the individual reactions of each of the elements of the rare earths. These latter he defines to be the oxides of the cerite metals as well as of the ytterite metals so-called, to which must be sometimes added the oxides of zirconium and thorium, since these, in their behavior, exhibit many analogies with those previously named.

From the introduction to the booklet we learn that these rare earths are always found in association with other elements and are found not only in Sweden and Norway, where they were first obtained, but also in Brazil, Canada, Russia, and other countries. In addition to their occurrence in minerals they have been found in various plant ashes, for instance, in ashes of tobacco and barley and also in bones. He calls attention to the fact that these rare earths have become well-known earths, that they have become numerous and among them may be enumerated the cerite metals—cerium, praseodymium, neodymium, lanthanum, samarium and of the yttrium metals (also known as gadolinium metals) which furnish a large number, yttrium, erbium, terbium, ytterbium, scandium, dysprosium, holmium, thulium, europium, gadolinium, and others. The author believes this list should be considerably extended because many of those here named are in all probability not simple bodies, but a mixture of various others yet unknown and very similar elements.

The system followed in the book is to set forth in each case: 1, the occurrence of the element in nature; 2, the principal characteristics of the element; 3, its combinations; 4, its reactions in the wet way; 4, its reactions in the dry way. The elements discussed in this way and the number of reactions described for each respectively, are as follows, in the order named: Zirconium, 24 wet reactions; thorium, 21 wet reactions; cerium, 24 wet reactions for cerous salts and 22 for ceric salts. Didymium—praseodymium and neodymium—19 wet reactions, 4 dry reactions; lanthanum, 20 wet reactions, no characteristic dry reactions offered.

Of the ytterite earths elements and their reactions, the following are treated respectively: Yttrium, 19 wet reactions, no dry reaction; erbium, 19 wet reactions, 2 dry reactions.

This little book is probably the only one in any language treating of these elements individually and collectively. It should certainly find a place in the library of every instruction laboratory, while for those specially interested in these rare earths and their study it will be invaluable.

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**Vectors and Vector Diagrams Applied to the Alternating-Current Circuit, with Examples of their Use in the Theory of Transformers and of Single and Polyphase Motors, etc.** By **William Cramp**, M.I.E.E., Consulting Engineer and Special Lecturer on Electrical Design in the University of Manchester, and **Chas. F. Smith**, M.I.E.E., Assoc. M. Inst. C.E., Lecturer in Electrical Engineering, the University of Manchester, and Director of the Electrical Engineering Laboratories, Municipal High School of Technology, Manchester. Price, \$2.50. New York: Longmans, Green & Company.

This book assumes that the reader has already a knowledge of alternating-current laws and of alternating-current machinery. In the early chapters the vector idea is developed and also the principles of vector algebra, using the symbolical method of Steinmetz with slight alterations in symbology. The problems of the design and characteristics of alternating-current machinery are solved by the use of vector methods, though the vector diagram occupies a relatively unimportant place. The treatment is simple and clear and easily followed by one having the presupposed familiarity with the subject. The work covers

quite completely the field of alternating-current machines and goes into more than the elementary details. It should lend itself particularly well to home study.

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**The Corrosion and Preservation of Iron and Steel.** By **A. S. Cushman** (Assistant Director and Chemist in Charge of Physical and Chemical Investigations, Office of Public Roads, United States Department of Agriculture) and **H. D. Gardner** (Director, Scientific Section, United States Paint Manufacturers' Association). 8vo, 373 pages, 68 illustrations. Price, \$4 net. New York: McGraw-Hill Book Company.

The senior author is also chairman of Committee U on Corrosion of Iron, and both authors members of Committee E on Preservative Coatings, American Society for Testing Materials. The work is very appropriately dedicated to Dr. C. B. Dudley, the lately deceased president of that society.

The book may be divided into two distinct sections, the experimental and theoretical part, and the practical part. The latter occupies Chapters VI to XII, and discusses most satisfactorily the preservative coatings for iron, such as with zinc, tin, copper, lead and other metals or alloys, with paints and pigments of various kinds, including the properties of paint vehicles.

This is, we think, by far the best part of the book, and is full of useful information intelligently discussed and practically set forth. This part of the book will be of interest and value to everyone having iron to protect from rusting under almost any conceivable condition.

The first five chapters are a mixture of observation, experiment and theory. As far as the observations and experiments are concerned, they are all interesting and well worthy of close study. In fact, the book contains many valuable records from which much insight into the problem can be obtained.

The authors classify the theories of corrosion as the "carbonic-acid" theory, the "peroxide" theory, and the "electrolytic" theory, and give their unqualified adhesion to the latter as the correct explanation. While not desiring to oppose the final conclusion to which the authors have arrived, the reviewer cannot refrain from noticing the partisan spirit which colors their interpretation of the observed facts. Many of their arguments are surprisingly weak, and really oppose rather than support their theory. For instance (page 110), "All substances in solution which contain hydrogen ions, such as acids, stimulate the corrosion of iron." But (page 111), "solutions of chromic acid . . . inhibit the rusting of iron."

The trouble here, and the chief defect of the authors' reasoning, seems too hasty generalization. The problems are so various, the corrosive agents so diversified, the conditions so multitudinous, the qualities of iron and steel so numerous that many causes of corrosion may be active even in one instance and to ascribe the whole effect to one cause is a risky conclusion. It is especially when the authors bring to their aid the assumptions of the theory of ionization in solution, and speak of various hypothetical ions as if they really existed and were directly under observation, that their explanations lose the merit of lucidity and pass into the field of the speculative and hypothetical. Their explanations then take on an apologetic tone, necessitated by the conflict between conclusions from their theory and the observed facts. The conflict is not between the "electrolytic" theory of corrosion *per se* and the facts, but between the facts and the language in which the electrolytic theory is expressed and set forth.

This explanation made, we commend the work highly to all interested in the facts and theory of the corrosion of iron, and particularly to those directly concerned in studying practical means of its prevention. The book is timely and will be of great service.

The paper, typography and press-work are exceptionally good. There is a long bibliography added.